Pro-cyclicality of the Basel Capital Requirement Ratio and Its Impact on Banks*

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Abstract
This paper proposes replacing the present Basel capital requirement with a new counter-cyclical measure. Optimally, (i) the Basel capital requirement ratio should depend on various economic factors such as the cyclical stage of GDP, credit growth, stock prices, interest rates, and land prices—hence, avoiding the expansion of bank loans during a boom period and a credit crunch during a sluggish period; (ii) the Basel minimum capital requirement rule should be different from country to country since the economic structures and the behavior of banks are different; and (iii) cross-border bank operation should follow the minimum capital requirement ratio where bank lending activities occur rather than the origin of the source of funds.

1. Introduction

The recent sub-prime loan crisis and the Asian financial crisis taught us various lessons. First, the pro-cyclicality of the Basel capital requirement was strongly recognized. Japan suffered for so long after the burst of the bubble in 1991. When the economy is in a downturn, banks tend to lend less as their capital declines. A credit crunch was one of the causes of the slow recovery of the Japanese economy in the 1990s. Second, banks reduce their lending to

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small and medium-sized enterprises (SMEs) and riskier businesses during economic recession. For Asian countries, SMEs play an important role in the economy. They are mainly financed through the banking sector and are therefore vulnerable to financial crises. Hence, stable bank lending is important in the Asian economy where bank loans account for a significant part of the financial market.

This paper focuses on the role of the Basel capital requirement and proposes a new pro-cyclical measure based on a simple general equilibrium model. How should we make the Basel II policy work better?

Some propose changing the level of minimum requirement from 8 percent to a higher level. Others propose raising the minimum capital requirements in good times and reducing them in times of recession, according to regulatory discretion. However, economies do not move in the same way. Some economies may be booming while others may be facing recession. Should the regulator raise the capital requirements for those banks situated in booming economies and reduce those for banks situated in weak economies?

There are different proposals to apply an adjustment factor to the Basel capital requirement ratio, thereby eliminating discretion by regulators. Himino (2009), for example, proposes a stock price index as an adjustment factor. This paper will explore adjustment factors, which should be based on various macroeconomic indicators such as GDP growth, credit growth, a stock price, and a real estate price index.

The Basel capital adequacy standards prompt a decline in bank credit due to a lower capital level, reflecting the increased risk of lending in bad times. Basel II employs statistical data; the data usually does not cover the entire credit cycle, however. Risk metrics based on statistical data usually cover only a part of a credit cycle, which tend to underestimate the risk in good times and overestimate it in bad times. Therefore, it is necessary to make the requirement cover various business cycles.

Previous proposals for the Basel capital requirement were based on a partial equilibrium model rather than on a general equilibrium model of the entire economy, as analyzed in this paper. Most of the existing papers do not show any theoretical model.

The model explained in this paper addresses the optimal Basel capital requirement ratio not only at the binding point where the bank's capital hits its minimum capital requirement but also at the interval where the bank's capital is greater than minimum required capital level.

This paper will address the following issues.

(i) The Basel capital requirement ratio should depend on various economic factors such as GDP, stock prices, interest rates, and land prices, based on a simple general equilibrium model. Previous papers have not shown any specific model and concluded that the capital requirement ratio would be better if it was adjusted based on stock prices or economic growth rate, or other economic indicators.
(ii) The Basel minimum capital requirement rule should be different for each country, because the economic structure is different from country to country. A simple general equilibrium model suggests that the optimal minimum capital requirement ratio does depend on the structure of the economy and the behavior of the bank.
(iii) Cross-border bank activity is analyzed by a two-country model. The minimum capital requirement ratio should follow where the assets are invested rather than the origin of the capital.

Empirical estimations are now underway. Some restricted cases of empirical results are reported in this paper. Japanese data show that the minimum capital requirement should have been lowered to −2.20 percent during the period starting from 1998:Q1 to 2008:Q4. U.S. data show that the minimum capital requirement ratio should have been increased to 4.42 percent during the boom period between 2002:Q4 and 2007:Q4, and it should have been lowered to −1.116 percent during the contraction period starting from 2001:Q1 to 2002:Q4.

This paper is organized as follows. Section 2 presents the simple profit maximization behavior of banks that are faced with downward sloping demand for loans. One case is the corner solution, whereby a bank is faced with the binding condition for the Basel minimum capital requirement ratio. Namely, a bank is faced with a capital/risk asset ratio of, say, 8 percent. The other case is that the Basel capital requirement ratio is not binding and a bank's capital is kept within the limit of the Basel capital requirement ratio. However, a bank has to pay a higher interest rate to absorb money from the financial market if its capital moves closer to the binding minimum capital requirement ratio because market participants expect that the bank will face difficulty if it hits the binding condition for minimum capital requirement. The lending behavior of the bank will be restricted when its capital requirement ratio becomes 8 percent.

Section 3 examines the optimal Basel capital requirement ratio that can stabilize bank lending. It shows that the optimal Basel minimum capital requirement ratio depends on land price, stock price, GDP, and interest rate. Section 4 presents some restricted cases of empirical results for Japan, the United States, and Canada. Section 5 explains the cross-border banking activities. A bank is assumed to lend money both in its domestic market and overseas market. The overseas loans should follow the minimum capital requirement of the target country rather than the originating country. On the other hand, its domestic loans should follow its domestic minimum capital requirement ratio. Section 6 concludes.

2. The model

2.1 Notations and assumptions

In our simple model, we use the following notations and assumptions.

Y: GDP

q_1: land price

q_2: stock price

π: profit of bank

L: amount of risky assets

i_L: interest rate on risky assets (such as bank loans)

i_B: interest rate on safe assets (such as government bonds)

A: bank capital, and its value depends on q_2

B: amount of safe assets (such as government bonds)

D: deposits and funds attracted from the short-term market by banks

θ^*: minimum capital adequacy ratio (CAR), say 8 percent under Basel II

L^*: desired amount of loans policy makers want to achieve

$\bar{L}$: maximum amount of loans that the bank could make at the given θ^*

$\theta \equiv A(q_2)/[K(q_1, q_2, Y, i_B)L]$: actual capital adequacy ratio

ρ^e: expected percent of risky loans that would result in default; it depends on macroeconomic variables such as land prices, stock prices, GDP, and the safe interest rate, i.e., $\rho^e = \rho^e(q_1, q_2, Y, i_B)$

$i_m(\theta - \theta^*)$: the interest rate that the banks pays for deposits and short-term borrowing, with i_m depending on the difference between θ and θ^*, and the smaller the gap $(\theta - \theta^*)$, the higher interest rate paid by banks i_m

$C(L,B,D)$: various costs from operations of the bank (e.g., personnel costs and equipment costs), which depend on the amount of risky bank loans, government bond investment, deposits, and funds attracted from the short-term market by banks

K: the average risk factor of the portfolio of risky loans; it is a function of $q_1, q_2, Y,$ and i_B. When GDP, land price, and stock price rise, banks are faced with a lower default risk from loans. When interest rate i_B is rising, banks tend to invest more in a safe asset (B), which reduces the default risk

2.2 Bank behavior

Each bank is assumed to maximize its profit. Each bank lends money to a risky sector and invests in risky securities. They are denoted by L. A certain fraction of the risky loans and investments (denoted L) default and the default ratio is expected to be a fraction ρ^e of the total risky investments. The expected default ratio depends on macro economic variables such as land prices, stock prices, GDP, and the safe interest rate.

A bank also invests in safe assets, such as government bonds, which are shown as B in equation (1).

A bank is funded by deposits and from short-term money market, as denoted by (D), where interest rate (i_m) will rise according to its proximity to the minimum capital adequacy ratio, for example 8 percent.

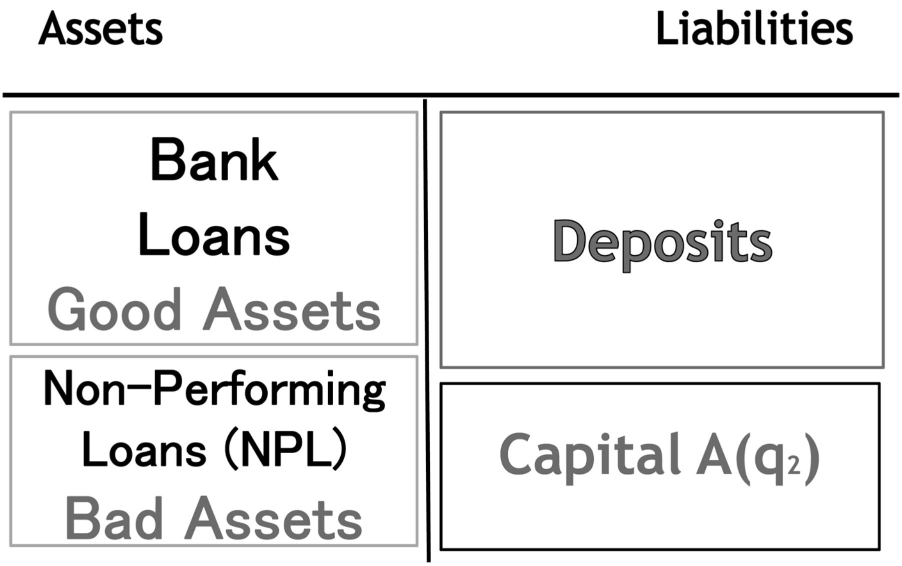
A bank pays the costs for lending, asset management, and fund-raising activities through payment for employees and computers, and so on, $C(L,B,D)$.

$$\pi = i_L(L)L + i_B B - \rho^e(q_1,q_2,Y,i_B)L - i_m(\theta - \theta^*)D - C(L,B,D)\,, \tag{1}$$

where $i_m = i_m(\theta - \theta^*)$ is the market rate of interest when banks raise their borrowing from the money market. The market interest rate is assumed to be dependent on whether banks have enough capital or not. If banks become closer to the corner solution, their capital is very close to the minimum capital adequacy ratio (θ^*), and the interest rate (i_m) they pay to the market goes up, because the market becomes skeptical about those banks regarding their profitability.

Banks maximize their profits (equation (1)) based on the following budget constraints (equation (2)); actual capital adequacy ratio has to be higher than the minimum capital requirement ratio θ^* (equation (3)), where $K(.)$ denotes the average risk factor of the portfolio of risky loans.

Figure 1. Bank's balance sheet



$$L + B = D + A(q_2) \tag{2}$$

and

$$\frac{A(q_2)}{K(q_1, q_2, Y, i_B)L} \geq \theta^* . \tag{3}$$

Equation (2) denotes the banks' balance sheet where banks make loans (L) and invest in safe assets (B), by absorbing funds from deposits and the short-term money market (D) shown in Figure 1. The banks' capital is shown as $A(q_2)$, which is assumed to depend on stock price q_2.

$K(q_1, q_2, Y, i_B)$ in equation (3) denotes the average risk factor of the portfolio of risky loans. Risk capital ratio K depends on macroeconomic factors, such as land prices (q_1), stock prices (q_2), GDP (Y), and the interest rates (i_B). When the land prices and stock prices are rising, banks are faced with a lower default risk ratio from loans. When the economy is booming and GDP (Y) is rising, banks will be faced with a lower default risk ratio. When the interest rate i_B is rising, banks tend to invest more in safe assets (B), which reduces the default risk. Therefore, K is denoted as $K = K(q_1, q_2, Y, i_B)$.

Equation (3) shows that banks must keep enough capital ($A(q_2)$) and their "capital adequacy ratio" must be greater than θ* (the minimum capital requirement).

2.2.1 Binding case The following shows maximum amount of loans banks can make when the bank's capital hits the minimum capital adequacy ratio (θ*):

$$L = \bar{L} = \frac{A(q_2)}{\theta^* \times K(q_1, q_2, Y, i_B)}, \tag{4}$$

When banks are bounded by the minimum capital adequacy ratio, the banks' loans are set to equation (4).

2.2.2 Non-binding case When the constraint (4) is not binding, each bank maximizes its profit (equation (1)) subject to equation (2).

The first-order conditions give the following relation:

$$\frac{\partial \pi}{\partial L} = i'(L)L + i_L(L) - \rho^e(q_1, q_2, Y, i_B) - i_m(\theta - \theta^*)$$
$$-i'_m(\theta - \theta^*)\frac{\partial \theta}{\partial L}[L + B - A(q_2)] - \frac{\partial C}{\partial L}[L, B, L + B - A(q_2)] = 0 \tag{5}$$

and

$$\frac{\partial \pi}{\partial B} = i'_B - i_m(\theta - \theta^*) - \frac{\partial C}{\partial B}[L, B, L + B - A(q_2)] = 0\,. \tag{6}$$

Equations (5) and (6) can be rewritten as follows:

$$i'_L(L)L + i_L(L) - \rho^e(q_1, q_2, Y, i_B) - i_m(\theta - \theta^*)$$
$$-i'_m(\theta - \theta^*)\frac{\partial \theta}{\partial L}[L + B - A(q_2)] - \frac{\partial C}{\partial L}[L, B, L + B - A(q_2)] = 0 \tag{7}$$

and

$$i'_B - i_m(\theta - \theta^*) - \frac{\partial C}{\partial B}[L, B, L + B - A(q_2)] = 0\,. \tag{8}$$

Equations (7) and (8) represent the bank's optimal amount of loans and the optimal demand of bonds, given q_1, q_2, Y, i_B, and θ*.

2.2.3 Loan demand When corporations are maximizing their profits, the demand for bank loans by corporations depend on (i) loan interest rate (i_L), (ii) the amount of output (Y) by corporations, and (iii) the land price as for the collateral (q_1):

$$L^d = L^d(i_L, Y, q_1), \tag{9}$$

where we assume

$$\frac{\partial L^d}{\partial i_L} < 0, \frac{\partial L^d}{\partial Y} > 0, \frac{\partial L^d}{\partial q_1} > 0 .$$

2.2.4 Market equilibrium From equations (7), (8), (9), and a macroeconomic model in the Appendix, we obtain a market equilibrium. In the market equilibrium, the equilibrium amount of loans can be written as follows:

$$L^m = L^m(q_1, q_2, Y, i_B, \theta^*) . \tag{10}$$

3. Optimal value of the minimum capital requirement

To obtain the optimal value of the minimum capital adequacy ratio set by the Basel Committee on Banking Supervision, we assume that stable bank lending is the objective of the Basel minimum capital requirement. Equation (3) denotes that the minimum capital requirement acts as a constraint, as it requires banks to retain enough capital to cope with future expected default losses accrued from asset management.

Monetary policy focuses on the stable rate of inflation and the stable business condition such as stable GDP growth. On the other hand, the Basel capital requirement is assumed to be focused on stable banking activities, namely, the stability of bank lending to enable borrowers to continue borrowing from banks. The optimal value of θ^* is set as follows.

The Basel Committee on Banking Supervision determines the optimal value of the minimum capital adequacy ratio by minimizing the fluctuations of bank loans based on the equilibrium value for bank loans obtained from:

$$\text{Minimize } (L^m - L^*)^2 \tag{11}$$

subject to

$$L^m = L^m(q_1, q_2, Y, i_B, \theta^*). \tag{12}$$

It follows that the optimal value of θ* is expressed as

$$L^* = L^m(q_1, q_2, Y, i_B, \theta^*). \quad (13)$$

Totally differentiating equation (13), and setting $L^m = L^*$, the following equation is obtained:

$$d\theta^* = a_1 dq_1 + a_2 dq_2 + a_3 dY + a_4 di_B, \quad (14)$$

where

$$a_1 \equiv -\frac{\partial L^m}{\partial q_1} \Big/ \frac{\partial L^m}{\partial \theta^*},\ a_2 \equiv -\frac{\partial L^m}{\partial q_2} \Big/ \frac{\partial L^m}{\partial \theta^*},\ a_3 \equiv -\frac{\partial L^m}{\partial Y} \Big/ \frac{\partial L^m}{\partial \theta^*},\ a_4 \equiv -\frac{\partial L^m}{\partial i_B} \Big/ \frac{\partial L^m}{\partial \theta^*}.$$

It follows from equation (14) that the optimal changes of θ* depends on land price, stock price, GDP, and interest rate.

When the capital adequacy ratio is binding, L^m is replaced with $\bar{L}$. Totally differentiating equation (4), and setting $\bar{L} = L^m$, the following equation is obtained:

$$d\theta^* = \varpi_1 dq_1 + \varpi_2 dq_2 + \varpi_3 dY + \varpi_4 di_B\,, \quad (15)$$

where

$$\varpi_1 \equiv -\frac{\theta^*}{K}\frac{\partial K}{\partial q_1},\ \varpi_2 \equiv \left(\frac{1}{K \times \bar{L}}\frac{\partial A}{\partial q_2} - \frac{\theta^*}{K}\frac{\partial K}{\partial q_2}\right),\ \varpi_3 \equiv -\frac{\theta^*}{K}\frac{\partial K}{\partial Y},\ \varpi_4 \equiv -\frac{\theta^*}{K}\frac{\partial K}{\partial i_B}.$$

4. The optimal value of the minimum capital adequacy ratio by use of a numerical example

Suppose that the land price is affected by some shock (α) as shown in the Appendix. According to this land market shock, stock price (q_2), interest rate (i_B) on bonds, and GDP (Y) will change. What is the value of θ* where the Basel Committee on Banking Supervision aims to stabilize bank loans in response to the land price shock (α)?

When the Basel Committee on Banking Supervision would like to stabilize bank loans in response to various economic shocks, the capital adequacy ratio should be adjusted according to the impact on land price, stock price, GDP, and the interest rate on safe assets.

The land price shock will affect the bank loan behavior and the expected default risk ratio will also be affected. To keep the bank loans stabilized, the minimum capital adequacy ratio has to be adjusted to cope with the macroeconomic shock coming from the changes in the land price. For example, think about a rise in the land price. Because of this shock, banks expand their loans. If bank regulators would like to reduce their loans to cope with a future increase of risky assets held in banks, the minimum capital adequacy ratio has to be adjusted to discourage banks' aggressive lending behavior.

On the other hand, during a period of economic recession, the demand for bank loans will also decline. To keep the bank loans unchanged, the minimum capital adequacy ratio θ^* has to be lowered to cope with sluggish demand for loans.

Therefore θ^* as expressed in equation (14) or equation (15) should vary depending on land price, stock price, GDP, and the safe interest rate.

Here is a numerical example using Japanese quarterly data (1996:Q1–2008:Q4):

$$d\theta^* = -(-0.00238)dq_1 + [0.299 - (-0.00853)]dq_2 - (-0.0369)dY - 0.0594di_B\,. \quad (16)$$

The first term in equation (16) is the magnitude of adjustment for the minimum capital requirement ratio when the land price rises (i.e., -0.00238), the second term is the impact from the stock price fluctuations ($0.299 - [-0.00853]$), the third term is the impact from GDP (Y) (-0.0369), and the last term is the impact from the safe interest rate. The second term, which is the impact of stock prices on the minimum capital adequacy ratio is divided into two parts, that is, its impact on capital (A) (0.299) and its impact on risk ratio (K) (-0.00853).

The preliminary estimates show that the biggest impact comes from the impact from the stock price on banks' capital (A), which is 0.299.

To what extent should the minimum capital requirement be adjusted in total?

If we take the period of 1998:Q1 to 2008:Q4 as an example, the minimum capital adequacy ratio should have been lowered to -2.20 percent to ensure that bank lending did not contract.

Changes in land price, stock price, GDP, and interest rate will all affect the expected default risk of banks and the banking behavior. Thus, the minimum capital requirement has to be adjusted to stabilize bank loans.

Of course the impact of various shocks will differ according to which market created the initial shock in the economy. Sometimes the shock arises from the property market (α), as in the case of the recent sub-prime loan crisis.

According to Revankar and Yoshino (2008), bank lending in Japan was significantly affected by the Basel minimum capital requirement. The decline in bank lending in Japan after the burst of the bubble can be explained by the Basel minimum capital requirement ratio, which was set at 8 percent for all the time rather than changing the value as is shown in this paper (see Table 1).

U.S. data show that the minimum capital adequacy ratio should have been increased by 4.42 percent during the boom period of 2002:Q4–2007:Q4, and it should have been lowered by −1.116 percent during the contraction period of 2001:Q1–2002:Q4.

The Canadian case shows that the minimum capital adequacy ratio should have increased by 0.9628 percent during the 2006:Q4–2007:Q4 period and it should have been lowered by −3.88 percent during the 2007:Q4–2008:Q4 period.

Table 1. Numerical results of the optimal minimum capital requirement ratio for Japan, the United States, and Canada

Japan	USA		Canada	
$d\theta = -2.20\%$ (8% − 2.20% = 5.80%) 1998:Q1–2008:Q4	$d\theta = -1.116\%$ (8% − 1.116% = 6.884%) 2001:Q1–2002:Q4	$d\theta = +4.42\%$ (8% + 4.42% = 12.42%) 2002:Q4–2007:Q4	$d\theta = +0.3706\%$ (8% + 0.3706% = 8.3706%) 2003:Q1–2004:Q4	$d\theta = +0.9628\%$ (8% + 0.9628% = 8.9628%) 2006:Q1–2007:Q4

Source: *Authors' calculations.*

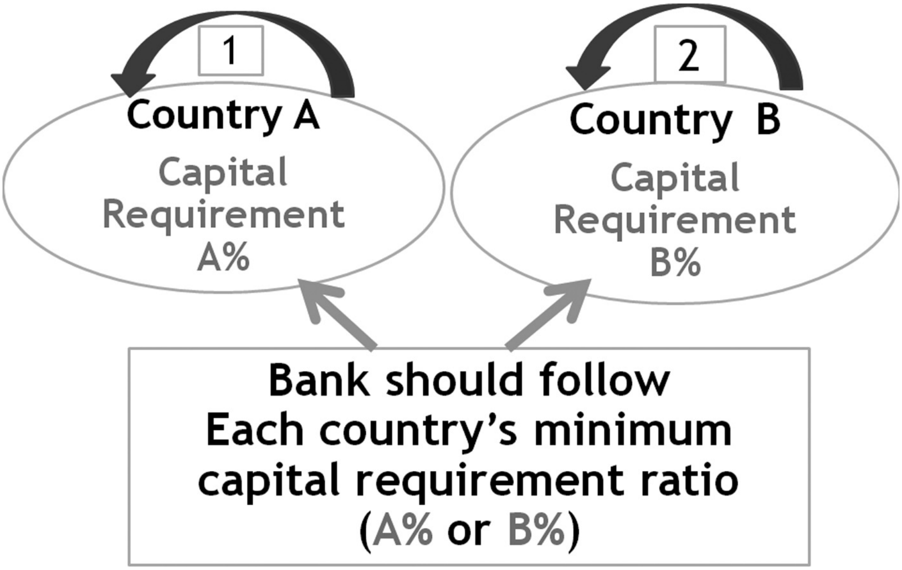
5. The case of cross-border banks

Figure 2 presents the case where a bank is operating its business in two countries (i.e., country A and country B). Let's assume that country A is in a boom and country B is in recession. Based on Section 3, the Basel minimum capital requirement ratio in county A (e.g., *A* percent) should be set higher than that of country B (e.g., *B* percent) to keep bank loans in a stable manner.

$$A\,\% > B\,\%$$

A bank prefers to set up its main office in country B because its minimum capital requirement ratio is smaller than country A. As is shown in Figure 2, a bank sets up its

Figure 2. Two country model (cross-border)

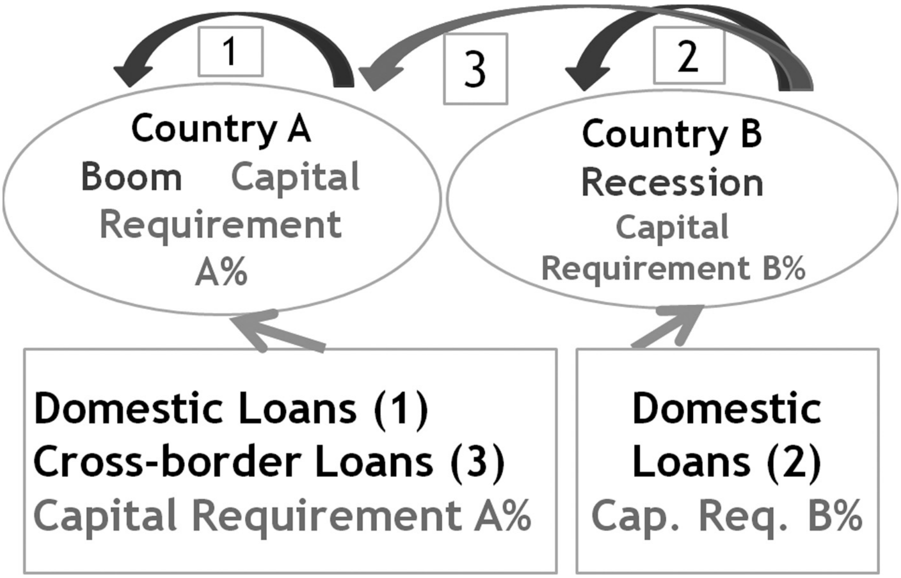


main headquarters in country B and expands its bank lending from country B to country A.

In this case, this bank should apply its minimum capital requirement ratio based on country A's minimum standard rather than the one in the originating country (B). Its bank lending in country B, denoted by arrow 2, should follow the minimum capital requirement ratio of country B. If the lending in country A comes from country B, denoted by arrow 3 in Figure 3, it should follow the minimum capital requirement ratio in country A, even though the original funds come from country B. If the bank lending originated from country B would follow the minimum capital requirement ratio of country B, the lending in country A would have expanded much more than desired and would have caused a bubble in country A.

Regulators have to monitor a bank's lending behavior with regard to the origin of the funds. An easier way to monitor is to force banks to separate their bank account into two parts based on the origin of the source. One account containing the origin of funds from its own country, denoted by arrow 1 in Figure 3, and another account is the fund coming from country B, denoted by arrow 3. Both funds, which are lending in country A, should apply the minimum capital adequacy ratio of country A.

Figure 3. Two country model (cross-border)



6. Conclusion

This paper presented the adjustment of the Basel capital requirement ratio in response to economic shocks, when banks would like to modify their bank loans in a stable manner.

The optimal Basel capital requirement ratio depends on (i) how banks behave and (ii) how macro economic factors, such as land price, stock price, GDP, and the market interest rate, react to each other and how they are influenced by economic shocks.

This paper concludes that the optimal Basel capital requirement should depend on banking behavior, the macroeconomic structure in each country, and the impact of economic shocks on each economy.

Because economic structure and banking behavior are different from country to country, this paper obtained the optimal value for the Basel capital requirement by use of a simple general equilibrium model for the banking sector. It concludes that the optimal minimum capital requirement should depend on various economic variables, such as land price, stock price, GDP, and the market interest rate. A numerical example was provided and shows how to adjust the Basel capital requirement to keep the lending unchanged in times of economic shock.

Cross-border bank operation should follow the minimum capital requirement ratio where bank-lending activities are going on rather than the origin of source of fund.

This model is still a very simple version, but other cases are being considered and the econometric models are also under estimation.

Appendix

Macroeconomic behavior of the economy

In a simple macroeconomic model, land price, stock price, GDP, and interest rate on government bonds are determined by the following equations:

$$q_1 = f(Y, i_B, q_2, \alpha)\ . \tag{17}$$

$$q_2 = g(Y, i_B, q_1, \beta)\ . \tag{18}$$

$$Y = \phi(L, i_B, q_1, q_2, \gamma)\ . \tag{19}$$

$$i_B = h(q_1, q_2, Y, i_m, M, \delta)\ . \tag{20}$$

These are the structural equations that will determine the four endogenous variables, namely, land price, stock price, GDP, and interest rate on government bonds.

Equation (17) is the determination of land price where land price fluctuates based on GDP, stock price movement, interest rate, and the shock to the land market such as the sub-prime loan crisis. Similarly, stock price—equation (18)—moves according to GDP, interest rate, land price, and the shock to the stock market. GDP—equation (19)—and interest rate on government bonds—equation (20)—are also determined by various economic conditions, where M is money supply. α, β, γ, and δ are exogenous shock variables that affect each market.

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