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Credit Channel and Risk-Based Capital Adequacy Requirements

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1 Introduction

Importance of bank lending in the propagation of exogenous shocks has been recognised in the literature. Such views are collectively called the “credit view”.¹ The credit view is that a negative shock (e.g. a monetary tightening) restricts the availability of credit to borrowers, thereby affecting the real economy. The credit view consists of two different views, namely the “bank-lending view” and the “balance sheet view”. According to the bank-lending view, banks cut back on lending in the wake of tight money, because they have less money to lend, even though there are good loans to be made. On the other hand, the balance sheet view implies that banks cut back on lending in the wake of tight money because borrowers are in bad shape. Thus, the two views have different implications. Nevertheless, both the views imply that a monetary tightening shifts the supply schedule of bank loans left, thereby affecting the real economy. This transmission mechanism of monetary policy is called the credit channel.

The quantitative importance of the credit channel may be dependent on institutional characteristics of the financial market. If banks can substitute from deposits to less reserve-intensive forms of finance (such as certificates of deposit, commercial paper, and equity), for instance, a reduction in bank reserves caused by a monetary tightening will not shift the supply schedule of bank loans. If borrowers have access to a variety of non-bank financial sources, for instance, a leftward shift of the supply

¹There is a large literature on the credit view. See, for instance, Walsh (1998 Ch 7) for a literature survey.

schedule of bank loans, if any, will not affect the real economy.² As such, it is argued in the literature that the importance of the credit channel is likely to diminish over time due to ongoing financial innovation and deregulation (e.g. Bernanke and Gertler 1995).

There may be institutional changes that make the credit channel of monetary policy more important, however. An example of such institutional changes may be the introduction of the risk-based capital standards. In July 1988, the bank supervisors of the G10 countries plus Luxembourg agreed to implement risk-based capital requirements, which took effect in 1989. This is known as the Basle Accord. Under the Accord, the Bank for International Settlements (BIS) requires bank supervisors to impose minimum risk-weighted capital-to-asset ratios of eight per cent on all internationally operating banks of their countries.³ The BIS gives positive weights and zero weights to risky components (e.g. commercial and industrial loans) and safe components (e.g. U.S. government securities) of banks' assets, respectively. This means that banks can raise their risk-weighted capital-to-asset ratios by substituting from loans to government bonds. If many banks shift their portfolios in this way at

²See Kashyap and Stein (1994) for further discussion on the institutional characteristics of the financial market that make the credit channel less important.

³The BIS proposed to revise the Basle Accord of 1988 on its consultative paper on "A New Capital Adequacy Framework" issued in June 1999. This paper focuses on the Accord of 1989, however. Santos (2001) provides a brief history of capital regulation since the Basle Accord of 1989. See, for instance, Altman and Saunders (2001) for further discussion on the BIS's new proposal of 1999.

the same time, the aggregate supply schedule of bank loans will shift inward, and a credit crunch will ensue.

In the U.S., for instance, the implementation of the risk-based capital standards coincided in timing with the slowdown in bank lending. Banks representing more than one-fourth of total U.S. assets did not meet the risk-based capital standards of the BIS as of December 1989 (see Avery and Berger 1991). These coincident events led economists to testing a hypothesis that the implementation of the risk-based capital standards caused a credit crunch.⁴ This means that the U.S. literature regards the implementation of the risk-based capital standards, per se, as an exogenous shock, and examines its one-time impacts on bank lending.

The focus of this paper is similar but different to that of the U.S. literature, however. First, this paper examines how the implementation of the risk-based capital standards affects the channel through which an exogenous shock (e.g. monetary policy) has influences on bank lending. That is, the focus is on the credit channel in the presence of the risk-based capital standards. Second, this paper focuses on the case of Japan. Under the Basle Accord, allowable components of bank capital are dependent on national regulations of individual countries, which creates difference in the effects of the risk-based capital standards on the credit channel between U.S.

⁴There is a relatively large empirical literature on the linkage between the Basle Accord and the U.S. credit crunch. See, for instance, Bernanke and Lown (1991), Haubrich and Wachtel (1993), Brian Hall (1993), Peek and Rosengren (1995), Berger and Udell (1994), and Brinkmann and Horvitz (1995).

and Japan.

A notable difference in banking structures between U.S. and Japan is that Japanese banks hold corporate equities.⁵ They hold the stocks of their regular customers as part of long-term relationship, and hence these stocks are not traded for profit. Due to the long-run growth of stock prices during the post-war period, latent capital gains from the stock holdings were substantial to the Japanese banks in the latter half of 1980s. Under the Accord, the banks are allowed to count a certain proportion of latent capital gains from stock holdings toward capital, which makes the risk-weighted capital-to-asset ratios for the Japanese banks vulnerable to fluctuations in stock prices. If stock prices fall substantially, latent capital losses from stock holdings will lower the risk-based capital-to-asset ratios of the Japanese banks. In extreme cases, the banks may choose to reduce their assets (with positive risk weights) by cutting back on lending in order to meet the capital standards of the BIS. Thus, an exogenous shock that have influences on stock prices can affect lending activities of the Japanese banks under the Basle Accord. The following sections aim to formalise this idea.

This paper is organised as follows. Section 2 reviews the risk-based capital standards of the BIS in the context of Japanese banks. Section 3 discusses a benchmark model for this paper. In particular, the “costly-state-verification” model (Townsend 1979), which captures asymmetric information problems pertain to financial transac-

⁵See, for instance, Aoki, Patrick, and Sheard (1994), Hoshi and Patrick (2000), and references therein for further discussion on the Japanese banking system.

tions, is employed.⁶ With this model, we derive incentive-compatibility constraints for a bank to make loans. This section also examines how exogenous shocks affect these constraints and thereby bank lending. Section 4 introduces the essence of the risk-based capital standards of the BIS into the model, and shows how, in addition to the incentive compatibility constraints, a capital adequacy constraint must also be satisfied. Section 5 concludes by comparing the implications derived from the model with the results of empirical works.

2 Summary of Risk-Based Capital Standards

Regulators have imposed high capital standards on banks in an attempt to protect depositors against bank failures. Prior to the Basle Accord, however, bank capital standards were stricter in some countries (e.g. the U.S.) than in other countries (e.g. Japan). As international banking activities increased due to the globalisation of finance, the regulatory discrepancy became a source of competitive inequality among international banks. Foreign banks, Japanese banks in particular, are argued to have increased their shares in the holdings of U.S. financial assets by taking advantage of lax capital regulations applied to them. While the U.S. regulators of banks were eager to tighten capital requirements in response to the S&L crisis, implementation of stricter capital standards was believed to put the U.S. banks at

⁶More specifically, this paper analyses the impact of the risk-based capital standards on the credit channel within a framework of the costly-state-verification model simplified by Romer (1996).

a greater disadvantage in competition with the foreign banks. This dilemma led the U.S. regulators to forging the consensus among the bank supervisors of developed countries that international convergence of bank capital regulations is required. In 1987, the Basle Committee of the Bank for International Settlements (BIS) published guidelines for harmonizing the capital adequacy requirements in the international banking market. Following the guideline, the bank supervisors of the Group of 10 countries and Luxembourg arrived at the agreement, which is the Basle Accord, that all international banks should be subject to the same minimum level of the capital-to-asset ratios.⁷

As the adequate level of capital for an individual bank depends on the riskiness of its portfolio, the capital standards under the Basle Accord is risk-adjusted. Banks' assets are classified and assigned weights (0, 10, 20, 50, and 100 percent) depending on their risks. As summarised in Table 1, a heavier weight is assigned to a riskier asset. For instance, holdings of government bonds and commercial loans to the non-bank private sector are included in 0% risk category and 100% risk category, respectively. Due to the risk weights, a portfolio shift can clearly affect the denominator even when the total value of assets is held constant. Thus, a bank may have an incentive to substitute from risky assets to safe assets, at least temporarily, if it needs to meet the risk-based capital standards.

In the calculation of the numerator of the capital-to-asset ratio, two types of capital are defined, namely Tier 1 (Core) and Tier 2 (Supplementary) capital. Under

⁷See Kapstein (1989) for a more detailed history of forging the Basle Accord.

Table 1: Major Items of Risk-Based Assets

0% risk category
· Cash
· Claims fully guaranteed by OECD governments
· Fixed interest securities issued by OECD governments with a residual maturity of up to 1 year
20% risk category
· Claims on multilateral development banks, and claims fully guaranteed by these institutions
50% risk category
· Loans fully secured by mortgage on residential property
100% risk category
· Claims on the non-bank private sector

Source: Maximilian J. B. Hall (1993)

the Basle Accord, an international bank is required to meet a capital standard:

$$\frac{\text{Tier 1} + \text{Tier 2} - \text{Deductible components}}{\sum w_i A_i} \geq 0.08. \quad (1)$$

where A_i and w_i denote the value of the bank's i th asset and its weight, respectively.

Tier 1 capital is common to all the signatory countries, which essentially consists of stockholders' equity. On the other hand, allowable components of Tier 2 capital are dependent on banking structures of individual countries (see Table 2). In contrast to the U.S. and U.K. banks, Japanese and West-German banks were allowed to hold corporate equities under the national regulations. Major Japanese banks, for instance, commonly held equities of their regular borrowers as part of long-term relationships, and these stocks were not traded for capital gains. Due to the steady

rise of stock prices during the post-war period in Japan, latent capital gains from the long-term holdings of stocks were substantial as of the late 1980s. The regulators of Germany and Japan successfully negotiated with those of U.K. and U.S. for inclusion of latent capital gains from stock holdings in bank capital. The Basle framework allows banks to count 45% of latent capital gains from holdings of corporate equities toward Tier 2 capital.⁸

Equation (1) shows that the capital-to-asset ratio for a Japanese bank is vulnerable to a change in stock prices. Suppose that stock prices sharply fall. The fall of stock prices will reduce Tier 2 capital of the numerator without affecting any other component. At the same time, it will be difficult for a bank to issue new equities. The upshot will be contraction of bank loans, as Japanese banks will have to curtail risky assets (i.e., commercial and industrial loans) with positive weights in the calculation of the risk-weighted capital-to-asset ratio in an attempt to meet the capital standards of the BIS. In other words, any exogenous shock that can negatively affect stock prices may have impacts on the real economy of Japan by shifting the supply schedule of bank loans inward. In this way, the capital regulations of the BIS may

⁸Wagster (1996) estimates the risk-weighted capital-to-asset ratios for 10 Japanese banks, finding that the ratios with and without latent capital gains were, on average, 12.35% and 2.11% as of 1987, respectively. As such, it was crucial for Japanese banks and their regulators to obtain a permission, from regulators of the other countries, to include latent capital gains from stock holdings into capital. See Kapstein (1989) for the negotiation between the signatory countries on the definition of bank capital. See also Maximilian Hall (1993) for cross-country difference in allowable components of Tier 2 capital.

Table 2: Allowable Components of Capital for Banks of U.S., U.K., and Japan

Type of Capital	Countries
Tier 1 Capital	
1. Common shareholders' equity	All
2. Disclosed reserves	All
3. Some form of preferred stock	U.S.
Tier 2 Capital	
1. Undisclosed reserves that have been charged against income	Japan
2. Revaluation Reserves	
· Formal revaluation carried to the balance sheet	U.K.
· Market values of securities not already reflected on the balance sheet (45 percent)	Japan
3. Hybrid debt-capital instruments:	
· perpetual debt	U.K.
· mandatory convertible debt	U.S.

Source: Wagster (1996)

strengthen the credit channel. The following two sections aim to formalise the credit channel for Japan in the presence of the risk-based capital standards. Section 3 sets up a benchmark model of the credit channel without the BIS's capital standards. From the model, two incentive compatibility constraints are derived, under which (1) a firm borrows from a bank, and (2) a bank makes loans to a firm. The section examines how exogenous shocks affect these incentive-compatibility constraints. Section 4 expands the model by introducing the risk-based capital standards. The objective is to examine how the capital standards affect the credit channel.

3 Benchmark Model

The basic structure of the model is as follows. Two types of agents are assumed, namely banks (lenders) and firms (borrowers). Each firm has a particular project whose expected return differs among the firms. A firm has two alternative options of investment, namely undertaking its risky project and holding a safe bond. Given the limited amount of internal funds, however, the firm has to borrow from a bank when it undertakes the project. If the project turns out unsuccessful, the firm will default. In such a case, the lender will have to audit the borrower. Auditing is costly, and the expected cost of auditing makes external funds more expensive to the borrower than internal funds. Taking into account the wedge between external funds and internal funds, the firm makes its investment decision. For the firm's project to be undertaken, a bank also must have an incentive to lend. Comparing the expected return from lending and the return from holding safe assets, the bank makes its decision. After discussing the assumptions in more detail, this section derives the incentive compatibility constraints for a firm and a bank to make the financial contract. Then, it examines how exogenous shocks affect these constraints.

3.1 Assumptions

Many risk-neutral firms are assumed to exist, each of which has a risky project. While these projects equally require one unit of input, their expected profits differ among the firms. In this sense, the firms are heterogenous. Each firm knows the

expected profit of its project that is not observable to any other firms or banks. Given internal funds, each firm makes investment decision between undertaking its risky project and holding riskless assets (e.g. government bonds). The firms are endowed with internal funds. For simplicity, let us assume that the amount of internal funds, denoted by S^F , is same across the firms. S^F is assumed to be less than one: $0 < S^F < 1$. This assumption implies that a firm needs $1 - S^F$ units of external funds to undertake its project.

Firms are assumed to borrow from banks.⁹ There is a number of risk-neutral banks. The banks are endowed with internal funds and deposits, and they are heterogeneous with respect to the amount of internal funds. Let S^B and D denote the amounts of internal funds and deposits, respectively. Given S^B and D , banks makes a portfolio choice between holding of safe assets (e.g. government bonds) and making loans. Since the focus is on the Japanese economy, a bank is assumed to hold equities of firms to which it makes loans. To simplify the relationship between a firm and a bank, the amount of an individual bank's internal funds is assumed to meet the following condition:

$$S^F(i) \leq S^B < S^F(i) + S^F(j) \text{ for } i, j = 1, 2, \dots, \text{ and } i \neq j, \quad (2)$$

where i and j are indices of firms. As will be discussed shortly, an individual bank has an incentive to borrow from one bank. Therefore, this assumption implies that an individual bank can make loans to one firm.

⁹This assumption is plausible when firms are small-to-medium size. There are prerequisites for a firm to raise funds in the bond markets of Japan, which are based on the firm size.

The debt contract between a firm and a bank is as follows. The amount of the repayment depends on the outcome of the project. If the project is successful, the firm fully repays the principal and interest. If the realised return of the project is insufficient for the full repayment, however, the firm only pays as much as it can.¹⁰ Let X denote the amount that the firm promises to repay. Since the principal is $1 - S^F$ by assumption, the loan interest rate, r_L , is expressed as

$$r_L = \frac{X}{1 - S^F} - 1. \quad (3)$$

In the case of default, the amount that the firm actually repays is increasing, up to X , in the outcome of the project.

This financial contract, however, provides a firm with an incentive to underreport the outcome of its project. If a firm defaults, a bank will audit it. The auditing is costly, and the expected cost of auditing will be passed on to the borrower, which makes external funds more expensive than internal funds. Assume that information on the result of auditing is confidential. If a firm defaults, all the lenders will have to audit it separately. For simplicity, assume also that the cost of auditing is common to all banks. In such a case, a firm has an incentive to minimise a wedge between external funds and internal funds by borrowing from one bank. Under these assumptions, financial relationship between a firm and a bank, if any, is simplified to be one-to-one.

For the debt contract between a firm and a bank to be made, (1) the firm must

¹⁰Ideally, the form of debt contract should be derived from optimization within a model. It is beyond the scope of this model, however. The modification will further this study.

have an incentive to borrow in order to undertake its project, and (2) the bank must have an incentive to make loans. For instance, the firm will not undertake the project if its expected return is less than the return of an alternative investment opportunity. The same argument holds for the bank's decision about making loans. The following subsection derives the incentive compatibility constraints for these two events to occur.

3.2 Incentive-Compatibility Constraints

The above-mentioned financial contract between a firm and a bank makes the expected pay-off to the bank dependent on the outcome of the firm's project. The outcome of the project is a random variable, however. For simplicity, assume that the outcome of the project is uniformly distributed between 0 and 2γ . The bank will not lend, if $2\gamma < X$, where X is the amount of the principal and interest. If the outcome is equal to or greater than X , then the firm will make full repayment of X to the bank. This happens with the probability of $(2\gamma - X)/2\gamma$. If the outcome is less than X , however, the bank will receive the whole outcome, which is on average equal to $X/2$, from the firm and spend the cost of auditing. This happens with the probability of $X/2\gamma$. Let R and c denote the expected pay-off to the bank and the cost of auditing, respectively. Assume that c is constant. Then, R can be expressed as a function of X :

$$R(X) = \frac{2\gamma - X}{2\gamma}X + \frac{X}{2\gamma}\left(\frac{X}{2} - c\right) \text{ for } X \leq 2\gamma. \quad (4)$$

Let R^{MAX} denote the maximum value of R . Equation (4) implies that R is maximised at $X = 2\gamma - c$, and that the maximised value is given as

$$R^{MAX} = \frac{(2\gamma - c)^2}{4\gamma}.^{11} \quad (5)$$

If R^{MAX} is strictly smaller than the return from holding safe assets, the bank will not lend to the firm. In other words, the following condition must hold when the bank lends to the firm.

$$(1 + r_B)(1 - S^F) \leq R^{MAX},$$

where r_B is the riskless interest rate. With equation (5), this necessary condition for bank lending can be written as

$$(1 + r_B)(1 - S^F) \leq \frac{(2\gamma - c)^2}{4\gamma}. \quad (6)$$

Equation (6) shows that the lending activity of the bank is dependent on the four exogenous variables: r_B , S^F , γ , and c .

The equilibrium interest rate on loans is uniquely determined as follows. Competition among the homogeneous banks will exhaust positive profits of lending, thereby making its expected rate of return equal to the riskless interest rate. Since the bank lends $(1 - S^F)$ units of funds to the firm, it must hold in equilibrium that:

$$R = (1 + r_B)(1 - S^F). \quad (7)$$

¹¹The first and second order conditions are

$$\frac{dR(X)}{dX} = 1 - \frac{X}{2\gamma} - \frac{c}{2\gamma} = 0, \text{ and } \frac{d^2R(X)}{dX^2} = -\frac{1}{2\gamma} < 0,$$

respectively. When c is zero, R^{MAX} is equal to the expected outcome of the project. As this is the costly-state-verification model, however, c is assumed to be strictly positive.

Given r_B and S^F , equation (7) uniquely determines the level of pay-off required for the bank to make loans. Substitute equation (7) into equation (4), and rearrange it:

$$X^2 - 2(2\gamma - c)X + 4\gamma(1 + r_B)(1 - S^F) = 0. \quad (8)$$

The solutions to equation (8) are

$$X = 2\gamma - c \pm \sqrt{(2\gamma - c)^2 - 4\gamma(1 + r_B)(1 - S^F)}.$$

If the necessary condition (6) is satisfied, equation (5) guarantees that the solutions are real numbers. It is also clear that the solutions are positive. Note, however, that X is defined as the sum of the principal and interest of loans. Since the principal is fixed at $1 - S^F$ by assumption, a larger X always means a higher interest on loans. The competition among the banks implies that the larger solution is implausible. Thus, the equilibrium level of X can be found as

$$X^* = 2\gamma - c - \sqrt{(2\gamma - c)^2 - 4\gamma(1 + r_B)(1 - S^F)}, \quad (9)$$

From equations (3) and (9), the interest rate on loans is uniquely determined in equilibrium:

$$r_L^* = \frac{X^*}{1 - S^F} - 1.$$

When a bank and a firm make the financial contract, the firm also has an incentive to borrow from the bank to undertake the project. The incentive compatibility constraint for the firm is derived as follows. Under the assumption of the uniform distribution, the expected outcome of the project is γ , from which the firm will make

payment to the bank. The expected amount of the firm's payment to the bank consists of two components. One is what the bank expects to receive, which is denoted by R . As equation (7) shows, this is equal to $(1 + r_B)(1 - S^F)$ in equilibrium. The other is the expected cost of auditing (or monitoring). If the firm defaults, the bank will audit, which is costly, and the cost will be passed onto the firm. Let M denote the expected cost of auditing. Since the auditing is required only when the project's outcome is less than X , the value of M in equilibrium can be written as

$$M = c \frac{X^*}{2\gamma} = \frac{c}{2\gamma} [2\gamma - c - \sqrt{(2\gamma - c)^2 - 4\gamma(1 + r_B)(1 - S^F)}]. \quad (10)$$

More compactly,

$$M = M(c, r_B, S^F, \gamma), \quad (11)$$

where

$$M_c > 0, \quad M_{r_B} > 0, \quad M_{S^F} < 0, \quad \text{and} \quad M_\gamma < 0.$$

After the deduction of the expected payment to the bank, the firm expects to obtain the following amount in equilibrium by undertaking the project:

$$\gamma - [R(X^*) + M(c, r_B, S^F, \gamma)] = \gamma - (1 + r_B)(1 - S^F) - M(c, r_B, S^F, \gamma).$$

The firm compares this with the return from the alternative investment opportunity. If the firm does not undertake the project, it can obtain $(1 + r_B)S^F$ by spending its internal funds on riskless assets. Thus, the incentive compatibility constraint for the firm can be written as

$$\gamma - (1 + r_B)(1 - S^F) - M(c, r_B, S^F, \gamma) \geq (1 + r_B)S^F. \quad (12)$$

Equation (12) shows that the firm's investment decision is vulnerable to changes in r_B , S^F , c , and γ , which may be interpreted as exogenous shocks.

3.3 Effects of Exogenous Shocks on the Incentive Compatibility Constraint

As equations (6) and (12) show, the incentive compatibility constraints for the financial contract to hold between a firm and a bank are functions of the four exogenous variables: r_B , S^F , c , and γ . This subsection examines how changes in these exogenous variables can affect the incentive compatibility constraints.¹² Changes in r_B represent exogenous shocks to the financial sector such as monetary policy. Changes in γ is exogenous shocks that affects the future profitability of the firm's project. One example is the firm's development of new technology, which is specific to the firm. Another example is real shocks that affect the economic outlook (such as the first oil embargo of 1973), which is common to all the agents in the economy. Changes in S^F represents exogenous shocks to the firm's internal funds. Under the assumption that the firm's internal funds can be approximated by its stock prices, a change in stock prices may be regarded as an example of such shocks.

Suppose that the necessary condition (6) holds for a bank with equality.

$$(1 + r_B)(1 - S^F) = \frac{(2\gamma - c)^2}{4\gamma}. \quad (13)$$

¹²This paper does not examine effects of changes in c , as these are hard to interpret in an economically sensible way.

This bank may be called a “marginal bank”. By taking total differentiation of equation (13), we obtain the following equation:

$$\underbrace{(1 - S^F)}_{+} dr_B - \underbrace{(1 + r_B)}_{+} dS^F = \underbrace{\frac{(2\gamma - c)(2\gamma + c)}{4\gamma^2}}_{+} d\gamma - \underbrace{\frac{(2\gamma - c)}{2\gamma}}_{+} dc. \quad (14)$$

Equation (14) is used to examine how exogenous shocks affect the behaviour of the marginal bank.

Table 3 summarises the effects of exogenous changes on the incentive compatibility for a marginal bank. The impacts of a rise in r_B on the incentive compatibility constraint for the marginal bank, for instance, are calculated from equation (14) as follows:

$$\left. \frac{dS^F}{dr_B} \right|_{d\gamma=dc=0} = \frac{1 - S^F}{1 + r_B} > 0,$$

and

$$\left. \frac{d\gamma}{dr_B} \right|_{dS^F=dc=0} = \frac{4\gamma^2(1 - S^F)}{(2\gamma - c)(2\gamma + c)} > 0.$$

In order for the marginal bank to have an incentive to lend to a firm, the firm must have a more profitable project or more internal funds (Proposition 1A). Its macroeconomic implication is that a monetary tightening may deprive banks of an incentive to lend to firms, thereby causing contraction of bank credit. This is consistent with the credit view. In a similar way, the impacts of a change in γ on the marginal bank’s incentive compatibility constraint can be calculated from equation (14). For

¹³It is plausible to assume that $2\gamma - c > 0$. As equation (4) shows, $X = 2\gamma - c$. Since X is the sum of the principal and interest, X cannot be negative. If $X = 0$, no loans are made. Thus, the only case of interest is that $X = 2\gamma - c > 0$.

the constraint to be satisfied, a decrease in γ requires a fall of r_B or an increase of S^F when the other variables are held constant (Proposition 1B). As the deterioration of macroeconomic outlook can make the prospect of business gloomy, its consequences are that firms (with limited internal funds) will lose credit worthiness, but that expansionary monetary policy can counter the contraction of bank credit. With equation (14), the consequences of a change in S^F can be examined in a similar way. When S^F decreases, a fall of r_B or a rise of γ is necessary in order to provide the marginal bank with an incentive to lend (Proposition 1C). In what follows, assume that the firm's internal funds can be approximated by its stock price. Then, a fall of stock prices have macroeconomic implications similar to those of the deterioration of economic outlook.

Table 3: Propositions 1

Effects of exogenous shocks on the bank's incentive compatibility constraint	
1A.	An increase in r_B (e.g. a monetary tightening) requires
	(i) S^F to rise, for given γ and c .
	(ii) γ to rise, for given S^F and c .
1B.	A decrease in γ (e.g. the oil embargo) requires
	(i) r_B to fall, for given S^F and c .
	(ii) S^F to rise, for given r_B and c .
1C.	A decrease in S^F (e.g. a fall of stock prices) requires
	(i) r_B to fall, for given γ and c .
	(ii) γ to rise, for given r_B and c .

As equation (12) shows, exogenous shocks can similarly affect the incentive-compatibility constraint for a firm. Suppose that the necessary condition (12) holds

with equality:

$$\gamma - 1 - r_B - M(c, r_B, S^F, \gamma) = 0 \quad (15)$$

This firm may be called a “marginal firms.” By taking total differentiation of equation (15), we obtain the following equation

$$\underbrace{(1 - M_\gamma)}_+ d\gamma - \underbrace{(1 + M_{r_B})}_+ dr_B - \underbrace{M_{S^F}}_- dS^F - \underbrace{M_c}_+ dc = 0, \quad (16)$$

Equation (16) is used to examine the impacts of exogenous shocks on the incentive compatibility constraint for a marginal firm.

Table 4 summarises the propositions derived from equation (16).¹⁴ The impacts of a rise of r_B on the incentive compatibility constraint, for instance, can be calculated as follows.

$$\left. \frac{dS^F}{dr_B} \right|_{d\gamma=dc=0} = -\frac{(1 + M_{r_B})}{M_{S^F}} > 0,$$

and

$$\left. \frac{d\gamma}{dr_B} \right|_{dS^F=dc=0} = \frac{(1 + M_{r_B})}{(1 - M_\gamma)} > 0.$$

Without an increase of the project’s expected return or the internal funds, a rise of r_B would deprive the marginal firm of an incentive to undertake the project (Proposition 2A). On the aggregate level, this implies that a monetary tightening will make the expected returns of the projects insufficient for the firms to undertake, which will result in a leftward shift of the demand schedule for bank loans. The effects of a change in γ on the incentive compatibility constraint for the marginal

¹⁴Note that the effects of each exogenous shock on the incentive-compatibility constraint facing the firm are the same as those on the incentive-compatibility constraint facing the bank.

firm can be similarly derived from equation (16). If the profitability of the project falls for some reason, the marginal firm will lose an incentive to undertake the project, unless the riskless interest rate falls or internal funds increase (Proposition 2B). Macroeconomic implications of this proposition are that the deterioration of economic outlook decreases investment of firms, and that monetary easing may prevent investment demand from decreasing. Proposition 2C, which is derived in a similar way, is that a decrease of S^F requires either a fall of r_B or an increase of γ in order for the incentive compatibility constraint to hold. An implication of this proposition is that a fall of stock prices will lead to a decrease of business investment, which may be cancelled out by expansionary monetary policy. As Tables 3 and 4 show, these propositions and their implications derived from the firm's incentive compatibility constraint are the same as those derived from the bank's one.

Table 4: Propositions 2

Effects of exogenous shocks on the firm's incentive compatibility constraint	
2A.	An increase in r_B (e.g. a monetary tightening) requires
	(i) S^F to rise, for given γ and c .
	(ii) γ to rise, for given S^F and c .
2B.	A decrease in γ (e.g. the oil embargo) requires
	(i) r_B to fall, for given S^F and c .
	(ii) S^F to rise, for given r_B and c .
2C.	A decrease in S^F (e.g. a fall of stock prices) requires
	(i) r_B to fall, for given γ and c .
	(ii) γ to rise, for given r_B and c .

4 Effects of the Risk-Based Capital Standards on the Supply of Bank Loans

The preceding section derives the incentive compatibility constraints for the financial contract to hold between firms and banks, thereby examining their responses to exogenous shocks. These responses may be affected by intervention from the government, however. As section 2 discusses, the bank supervisor requires internationally operating banks to meet the risk-based capital standards under the Basle Accord. The implementation of the capital adequacy requirements imposes a new restriction on the banks. More specifically, international banks are required to keep their risk-weighted capital-to-asset ratios equal to or greater than eight per cent. Taking into account the new restriction, the banks will make portfolio choice, which will in turn affect the availability of bank credit to the firms. This section examines how the banks respond to exogenous shocks when they must meet the risk-based capital standards. It will be shown that even if the incentive-compatibility constraints (6) and (12) are satisfied, the project may not be undertaken. For this purpose, this section extends the benchmark model by introducing the risk-based capital standards as a new constraint for the banks.

4.1 Implementation of Risk-Based Capital Standards

In order to introduce the risk-based capital standards into the benchmark model, it is necessary to specify the components of a bank's balance sheet. The benchmark

model assumes that a bank is endowed with internal funds (S^B) and deposits (D). The liability side of a bank's balance sheet is composed of these two items. Given S^B and D , a bank makes an investment choice between holding riskless bonds (B) and making risky loans (L). The benchmark model also assumes that a bank must hold its borrower's equities (S^F), which is established as an important constituent of relationship between Japanese banks and their regular customers. From these assumptions, the asset side of a bank's balance sheet is comprised of B , L , and S^F .

As the discussion 2 suggests, it will be shown that latent capital gains to a bank from the stock holdings play an important role in what follows. This means that the setting of the benchmark model needs to be modified with the introduction of time. Suppose that a bank is endowed with internal funds and has no liability at time 0. Let S^B denote the value of the internal funds. Then, the liability side of the bank's balance sheet is initially comprised of only S^B . Suppose that a firm issues equities at time 0. Let S_0^F denote the initial value of the equities. S_0^F is smaller than S^B . These assumptions are same as those of the benchmark model. Assume, however, that a bank purchases the equities of the potential borrower before making loans. This newly introduced assumption implies that the bank's assets are comprised of S_0^F and vault cash before making loans. Suppose that deposits (D) are given to the bank at time 1 after it purchases the firm's equities. With D and the vault cash, the bank makes loans to the firm. Any excess funds are spent on purchasing safe bonds. Let L and B denote the volumes of loans and bonds, respectively. Then, L and B appear on the asset sides of the bank's balance sheet at time 1. The market value

of the firm's equities, which is the other component of the bank's assets, is likely to be different at time 1. Let S_1^F denote the market value of the firm's equities held by the bank at time 1. Then, the asset side of the bank's balance sheet is comprised of L , B , and S_1^F at time 1. On the other hand, the liability side is comprised of D , S^B , and $S_1^F - S_0^F$. The change in the bank's balance sheet is summarised in Table 5.¹⁵ If the bank must meet the capital adequacy requirements at time 1, the bank will make investment decision at time 0 considering the expected composition of its balance sheet at time 1.

Table 5: Change on a Bank's Balance Sheet

Before lending		After lending	
Assets	Liabilities	Assets	Liabilities
S_0^F	S^B	L	D
Cash		B	S^B
		S_1^F	$S_1^F - S_0^F$

Under the Basle Accord, the capital standards are risk-based, which has two distinctive characteristics. One is that each component of a bank's assets is risk-weighted when its capital-to-asset ratio is calculated. As was discussed in section 2, riskless bonds and risky claims on the non-bank private sectors are given weights 0

¹⁵Latent capital gains from the stock holdings are defined as the difference between the market value and the acquisition value of the equities. Under the accounting rule of Japan, however, the book values of equities held by Japanese banks are based on the acquisition values. See, for instance, Kuroda, Kotani and Ogawa (1994) and Ogawa and Kubota (1995) for issues of bank accounting in Japan.

and 1, respectively (see Table 1). This implies that B is excluded from the denominator of the risk-weighted capital-to-asset ratio. The other one is that allowable components of bank capital include a certain proportion of latent capital gains from the stock holdings. Suppose that the values of equities held by a bank increases from S_0^F to S_1^F . Then, latent capital gain, which is expressed as $S_1^F - S_0^F$, must be included in the numerator of the bank's capital-to-asset ratio. Thus, a bank is required to meet the following risk-based capital adequacy requirements at time 1:

$$\frac{S^B + \beta(S_1^F - S_0^F)}{B \times 0 + (L + S_0^F) \times 1} \geq \alpha, \quad (17)$$

where both α and β are positive constants. In practice, α and β are equal to 0.08 and 0.45, respectively.

Taking into account the capital standard (17), a bank decides at time 0 whether to lend to a firm. As a bank cannot know the future value of a firm's equities, however, S_1^F should be replaced with its expected value in the capital adequacy constraint for the bank.

$$\frac{S^B + \beta(E[S_1^F] - S_0^F)}{L + S_0^F} \geq \alpha.$$

where $E[S_1^F]$ denotes the value of S_0^F expected at time 0. This can be simplified by an assumption for the benchmark model that each firm's project requires one unit of input. This assumption implies that L is equal to $1 - S_0^F$.¹⁶ By substituting

¹⁶As was discussed in the preceding section, the expected cost of auditing makes external funds more expensive to the borrower than internal funds. For this reason, a firm has no incentive to borrow more than $1 - S_0^F$.

$1 - S_0^F$ into L , we obtain the following condition.

$$S^B \geq \alpha + \beta S_0^F - \beta E[S_1^F]. \quad (18)$$

This is the new constraint introduced for the bank by the implementation of the risk-based capital standards.

4.2 Effects of Exogenous Shocks on the Capital Adequacy Constraint

The constraint (18) implies that there is a minimum level of S^B required for a bank to make business loans. To show this more clearly, it is necessary to express $E[S_1^F]$ as a function of the exogenous variables defined in the previous section. An important assumption is that the value of a firm's equities is equal to its net worth. If a firm undertakes the project, its net worth will be the expected outcome of the project less the expected payment to the bank at time 1. The expected outcome of the project is γ under the assumption of uniform distribution. The expected payment from the firm to the bank consists of the expected pay-off to the bank and the expected cost of auditing. Because of the competition among the banks, the expected pay-off to the bank must be equal to the return from the safe assets. Thus, the net worth of a firm that undertakes the project will be

$$E(S_1^F) = \gamma - (1 + r_B)(1 - S_0^F) - M(c, r_B, S_0^F, \gamma).^{17} \quad (19)$$

¹⁷This is equal to the left-hand-side of the necessary condition (12) for a firm to undertake its project in the benchmark model.

With equation (19), the capital adequacy constraint (18) can be written as

$$S^B \geq \alpha + \beta S_0^F - \beta[\gamma - (1 + r_B)(1 - S_0^F) - M(c, r_B, S_0^F, \gamma)]. \quad (20)$$

This shows that the minimum level of the bank's net worth required for it to make loans depends on the exogenous variables: γ , r_B , S_0^F , and c .

From the condition (20), we can derive the impacts of exogenous shocks on the banking behaviour under the risk-based capital standards. Let S_{MIN}^B denote the minimum level of S^B that satisfies the condition (20):

$$S_{MIN}^B = \alpha + \beta S_0^F - \beta[\gamma - (1 + r_B)(1 - S_0^F) - M(c, r_B, S_0^F, \gamma)]. \quad (21)$$

The impacts of a rise in r_B , for instance, are calculated from partial differentiation of S_{MIN}^B with respect to r_B in equation (21).

$$\frac{\partial S_{MIN}^B}{\partial r_B} = \beta[(1 - S_0^F) + M_{r_B}] > 0.$$

If the riskless interest rate rises, a bank is required to have higher initial net worth in order to make loans when the other variables are held constant. In other words, a hike of the riskless interest rate will make banks with low net worth unable to meet the capital standards in future. If a substantial number of banks give up lending in response to a hike of the interest rate, aggregate bank credit will contract. The impacts of changes in γ and S_0^F on S_{MIN}^B can be derived in a similar way. Partial differentiation of S_{MIN}^B with respect to γ yields

$$\frac{\partial S_{MIN}^B}{\partial \gamma} = -\beta[1 - M_\gamma] < 0.$$

If the expected outcome of the project decreases, a bank is required to have a higher level of initial net worth when the other variables are held constant. A macroeconomic implication is that the deterioration of economic outlook will make banks with low net worth unable to make loans, thereby resulting in contraction of bank loans. Likewise,

$$\frac{\partial S_{MIN}^B}{\partial S_0^F} = \beta[M_{S_0^F} - r_B] < 0.$$

A decrease in the firm's net worth also requires a bank to have a higher level of internal funds when the other variables are held constant. The implication is that a fall of stock prices will deprive banks with lower net worth of ability to meet the capital standards, thereby reducing the availability of funds to bank-dependent firms. These results are summarised as propositions in Table 6.

Table 6: Propositions 3

Effects of exogenous shocks on the bank's capital adequacy constraint	
3A.	An increase in r_B (e.g. a monetary tightening) requires a higher S_{MIN}^B , for given γ , S_0^F and c .
3B.	A decrease in γ (e.g. the oil embargo) requires a higher S_{MIN}^B , for given r_B , S_0^F , and c .
3C.	A decrease in S_0^F (e.g. a fall of stock prices) requires a higher S_{MIN}^B , for given r_B , γ and c .

5 Conclusion

Under the Basle Accord, the Bank for International Settlements requires bank supervisors of the signatory countries to impose capital adequacy requirements on international banks. As the implementation of the capital standards means a new constraint for the banks to satisfy, it can affect the banking behaviour. If exogenous shocks make the new constraint bind over a wider range of circumstances, for instance, these shocks will reinforce the credit channel. Thus, the implementation of the capital standards may have implications on the credit view.

Section 2 summarises the capital standards under the Basle Accord. The capital standards have two distinctive characteristics. One is that allowable components of bank capital include latent capital gains from the stock holdings. As the banks of Japan are allowed to hold common equities, the risk-based capital standards make the numerators of their capital-to-asset ratios vulnerable to changes in stock prices. The other characteristic is that assets are risk-weighted. Highly safe assets (such as sovereign bonds issued by any OECD country) are given zero weights and excluded from the denominator of the capital-to-asset ratio. Consequently, a bank may substitute from risky loans to holdings of safe bonds, at least temporarily, in an attempt to meet the capital standards. Thus, these two characteristics imply that banks will reduce loans in response to a fall of stock prices, reinforcing the balance sheet channel.

This paper aims to formalise the impacts of the implementation of the risk-based

capital standards on the credit view. Section 3 sets up a benchmark model within a framework model of the costly-state-verification model, from which the necessary condition for a firm to borrow from a bank and the necessary condition for a bank to lend to a firm are derived. These two necessary conditions must hold at the same time when a firm and a bank make the financial contract. These incentive compatibility constraints are used to examine how a bank and a firm respond to exogenous shocks. The implications are consistent with the credit view. Section 4 introduces the risk-based capital standards into the benchmark model. The risk-based capital standards are formalised as another constraint for a bank to satisfy. From this constraint, a minimum level of a bank's net worth required for it to make loans is derived. Then, the impacts of exogenous shocks on the required level of a bank's net worth are examined. The implication is consistent with the discussion in section 2: negative macroeconomic shocks increase the minimum levels of net worth required for banks, and banks with lower net worth reduce loans in an attempt to meet the capital standards.

Is this implication supported by empirical studies? Gibson (1997), for instance, finds that the deterioration of banks' health caused decline in investment in Japan during the early 1990s. Although this event coincided in timing with the implementation of the risk-based capital requirements, it is not clear whether this happened by making the capital standards more binding. Ito and Sasaki (1998) specify an increase of industrial loans as a linear function of the current and lagged risk-weighted capital-to-asset ratios, controlling for the effects of macroeconomic shocks and non-

performing loans. With the micro data of 85 banks between 1990 and 1993, they estimate the linear functions for the city banks, the regional banks, and the trust banks. Consistent with the credit crunch hypothesis, they find that the coefficients of the capital-to-asset ratios are significantly positive for the city banks. They find, however, insignificant coefficients of the risk-weighted capital-to-asset ratios for the other two types of banks. Using a longer sample in a similar study, Woo (1999) also finds no evidence for the credit crunch hypothesis during most of the 1990s except for 1997.

Peek and Rosengren (1997) provide a possible explanation for the weak empirical support for the credit crunch hypothesis. They point out two important characteristics of the Japanese banking system in the early 1990s. One is the historically strong relationship between the Japanese banks and their regular customers. This implies that the Japanese banks were essentially reluctant to cut back on lending to the long-term domestic customers. The other characteristic is the active lending operations of the Japanese banks in foreign countries at that time. In the U.S., for instance, they accounted nearly one-fifth of commercial and industrial loans. This implies that the Japanese banks can reduce loans to the borrowers in the U.S. to meet the capital standards. Using the semi-annual panel data on the U.S. branches and subsidiaries of 29 Japanese banks, they estimate the relationship between an increase in lending of the branches and subsidiaries (adjusted by the size of total assets) and their parent banks' risk-weighted capital-to-asset ratios. They conclude that a shock to the Japanese stock market can be transmitted to the U.S. through

the decline in bank lending through the U.S. branch of the Japanese banks. The simple model of this paper does not take into account the overseas operations of the banks. Modelling the risk-based capital standards in the international portfolio choice will further the literature.

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