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EMPIRICAL STUDIES ON THE RECENT DECLINE IN BANK LENDING GROWTH : AN APPROACH BASED ON ASYMMETRIC INFORMATION

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ABSTRACT

This paper investigates the background to recent sluggish bank lending taking the existence of asymmetric information into consideration. The estimation model is a structural one in which the loan supply curve has a backward-bending shape. Panel data of Japanese individual banks is used. The main results of this paper are as follows. (i) Only during one sub-period (FY1990-92) does the structural model fit fairly well with the loan supply curve having a backward-bending shape. This indicates that in the recent recession after the bubble burst, the degree of asymmetric information intensified because future financial conditions for borrowers became more uncertain than ever. Therefore banks were obliged to use loan rates as screening devices. (ii) According to the estimation results of reduced-form lending margin functions, the decline in funding cost reduced the lending margin by almost the same degree. However, the rise in the ratio of bad loans significantly raised the lending margin. This is considered one important reason behind the delayed effects of cumulative monetary relaxation.

KEY WORDS: Asymmetric Information; Bank Lending; Bad Loans

JEL CLASSIFICATION: E4

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I. Introduction

Recently, monetary policy has not been constrained by exchange rate considerations in Japan and the Bank of Japan has reduced its official discount rate successively since July 1991, as a result of which, bank loan rates have declined substantially. The bank lending growth, however, is still sluggish and monetary relaxation has not yet been confirmed in quantitative indices. Concerning the causes of this phenomenon, many arguments have been put forward.

We can divide these arguments roughly into two categories. One emphasizes demand-side factors and the other is related to supply-side factors. As for demand-side factors, structural factors like increased financing through capital markets, as well as cyclical factors, are frequently mentioned.[1] On the other hand, with regard to supply-side factors, the change in bank lending attitudes toward becoming more strict is often pointed out. This view reflects various aspects such as a deterioration in the creditworthiness of borrowers, the existence of balance sheet adjustment due to BIS regulations and the increase in non-performing assets.[2] In addition, there is another view connecting the rise in the share of public finance to the strict lending attitude of private banks.

Reviewing empirical analyses on this issue, however, there has been no case where loan demand and supply functions are simultaneously estimated using panel data, though recently the number of analyses using panel data[3] has been increasing. It is thus thought that there is room for improvement in this respect.

The purpose of this paper is to verify the change in bank lending behavior in the recent recession after the bubble burst by simultaneously estimating both loan demand and loan supply functions. Specifically, this paper investigates the frequently asked questions as follows. In the recent recession, have banks used loan rates to screen borrowers with high default risk because of the existence of asymmetric information? As a result does the loan supply curve have a backward-bending shape? Has the increase

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[1] As for another example, Yamaya (1994) suggests that the drop in rate of return on capital leads to a reduced incentive to invest, resulting in sluggish bank lending growth. For details, see "*Keizaikyoushitsu* [lecture on the current economic situation] " Nihon Keizai-Shinbun, February 26, 1994)

[2] For example, Iwata (1994) argues that sluggish bank lending growth is attributed to balance sheet adjustment due to the increase in non-performing assets. For further details, see "*Keizaikyoushitsu* [lecture on the current economic situation] " Nihon Keizai-Shinbun, March 18,1994.

[3] With regard to the advantages of using panel data, we can list the following two points; (i) compared with time series data, the degree of freedom is significantly improved so that we can detect the structural change in a relatively short time span; and (ii) we can distinguish between variants resulting from observed peculiarity of economic agents and those caused by other factors.

in bad loans and deterioration of financial conditions for borrowers significantly shifted the loan supply curve inward, inducing a slowdown in lending growth? Why has the lending margin widened despite lower funding costs? Is it because banks have demanded higher risk premium on loans than before? These questions[4] will be clarified in this paper.

This paper is organized as follows. In Section II, we observe the characteristics and background to bank lending behavior in recent years through time-series data. In Section III, previous empirical analyses are reviewed and their shortcomings with respect to the points of focus in this paper made clear. Section VI explains the basic model based on the function of loan rates as a screening device associated with asymmetric information. In Section V, after presenting the specification of loan demand and supply functions, we conduct the original empirical studies. Section VI is the conclusion and discussion on the limitation of analyses in this paper.

The major conclusions of this paper are summarized below.

(i) As a result of the estimation of a non-linear structural model taking into consideration the function of loan rate as a screening device associated with asymmetric information, only during one sub-period (FY1990-92) does the model fit fairly well with the backward-bending loan supply curve. This result may imply that in the recent recession after the bursting of bubble economy, because future financial conditions for borrowers became more uncertain than ever, the degree of asymmetric information intensified and banks were obliged to use loan rates as screening devices through which they gauged the default risk of borrowers .

(ii) Simulation using the estimated equations indicates that the degree of excess demand in the loan market was almost the same between FY1990 and FY1992. Breaking down Japanese banks into three categories, the degree of excess demand in the case of city banks is relatively high compared to other categories.

(iii) In addition, according to the estimation results of reduced-form lending margin functions, the lower funding cost reduces the lending margin by almost the same degree. However, the increase in bad loans, as well as the deterioration in borrowers' financial conditions, has significantly raised the lending margin. We can list this as one of the important reasons accounting for the delayed effects of cumulative monetary relaxation.

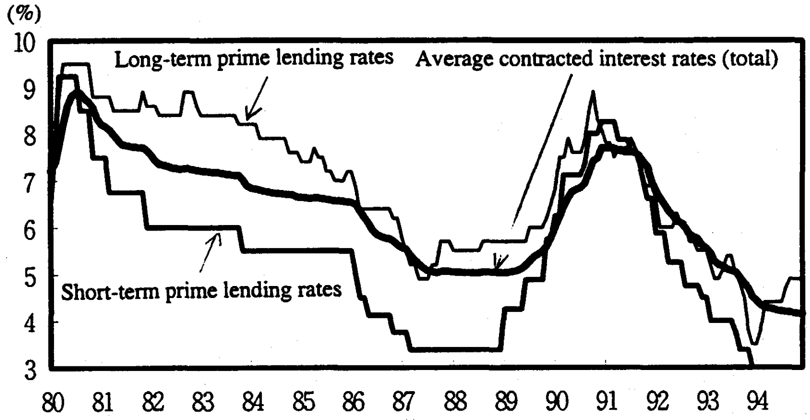
[4] Although not tested directly, Ariga et.al (1994) has almost the same motivation.

II. Characteristics of Bank Lending Behavior in Recent Years

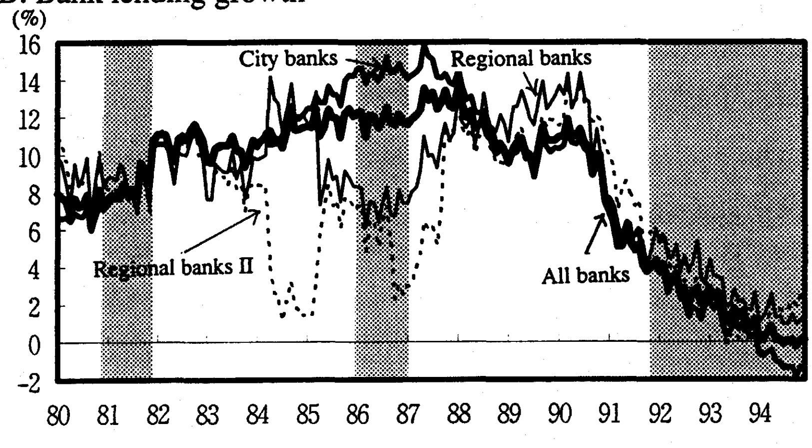
Reflecting the fall in market rates due to cumulative monetary relaxation since July 1991, banks have lowered loan rates smoothly and present levels are extremely low from a historical perspective. The bank lending growth, however, remains sluggish so that monetary relaxation has not yet been confirmed in quantitative indices. This phenomenon is quite different from the past monetary relaxation periods (Figure 1). In the following, through the observation of time-series data, we approach the background to this phenomenon .

(Figure 1) Bank Lending Behavior in Recent Years

A. Movement of bank lending rates



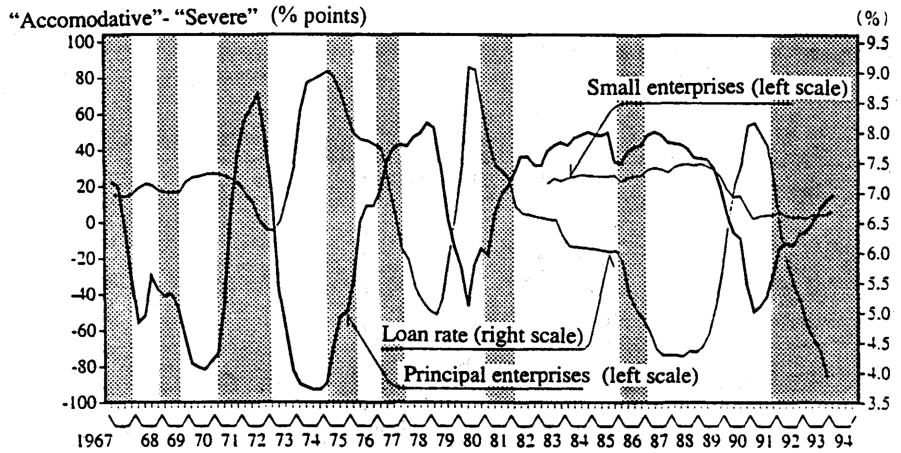
B. Bank lending growth



(Notes) Shaded areas indicate periods of declining call rate.
(Source) *Economic Statistics Monthly*, Research and Statistics Department , Bank of Japan

Concerning the cause of this phenomenon, one of the main points of our argument is that the deterioration of bank balance sheets, i.e. increase in the share of less profitable assets and non-performing loans, may have contributed to the slowdown in lending growth, although demand factors reflecting the prolonged recession have also been dominant. Figure 2 compares the DI (diffusion index) of financial institutions' lending attitudes for principal enterprises (all industries) with the average contracted interest rates on loans and discounts from this perspective.

(Figure 2) The DI of Financial Institutions' Lending Attitudes and Loan Rate



(Notes) Shaded areas indicate periods of declining call rate.
(Source) *Short-Term Economic Survey of Enterprises in Japan*, *Economic Statistics Monthly*, Research and Statistics Department, Bank of Japan.

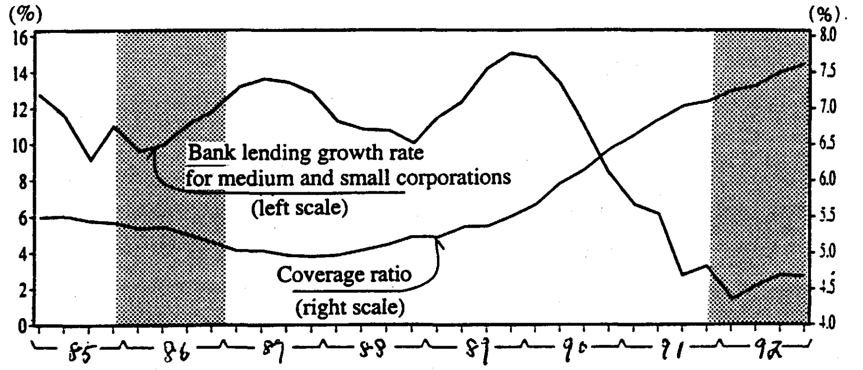
The DI of financial institutions' lending attitudes ("accommodative" minus "severe") turned below zero in 1991. So far, it was said that there existed a stable negative correlation between the lending attitude DI and loan rates. However, while loan rates have significantly declined since 1991, the improvement in the lending attitude DI remains relatively limited.

In addition, we can point out the following fact as one of the characteristics peculiar to the monetary relaxation period since late 1991. While, as a whole, the number of firms deeming that the lending attitude of financial institutions is "accommodative" has increased, in the case of small firms, to the contrary, the number judging that lending attitudes are "severe" has also increased[5]. Meanwhile, it is

[5] It is said that small firms, especially in non-manufacturing industries, are very dependent on bank loans and that in many cases they made investment decisions in response to the active digging-up of loan demand by banks. Therefore, it is highly probable that the change in bank lending attitudes toward becoming more strict has had a considerable effect on the slowdown of investment.

sometimes pointed out that the rapid growth of guarantee obligations by the Credit Guarantee Corporation (Figure 3), as well as the rise in public finance's share (Figure 4), is a sign that the lending attitude of private banks has become more restrictive.

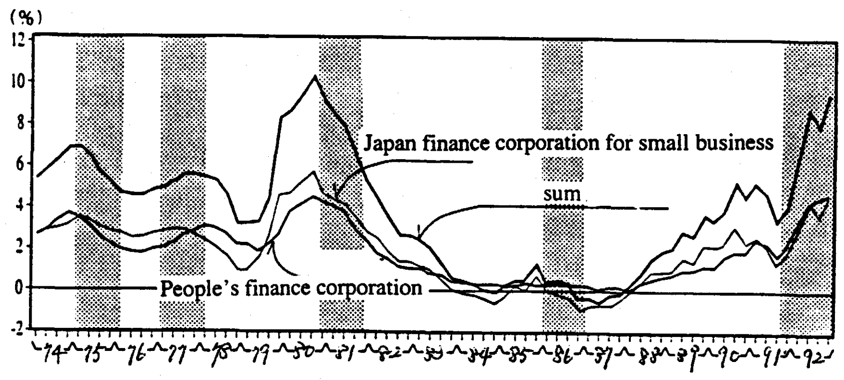
(Figure 3) Growth of Guarantee Obligations by Credit Guarantee Corporation



(Notes) 1. Coverage ratio is defined as the ratio of guarantee obligation outstanding by credit guarantee corporation to loan outstanding toward small and medium corporations
2. Shaded areas indicate periods of declining call rate.

(Source) *Short-term Economic Survey of Enterprises in Japan*, *Economic Statistics Monthly*, Research and Statistics Department, Bank of Japan.

(Figure 4) The Share of Public Finance to Increase in Total Lending



(Notes) 1. The increase in total lending consist of all banks, Japan finance corporation for small business and People's finance corporation.
2. Shaded areas indicate periods of declining call rate.

(Source) *Economic Statistics Monthly*, Research and Statistics Department, Bank of Japan.

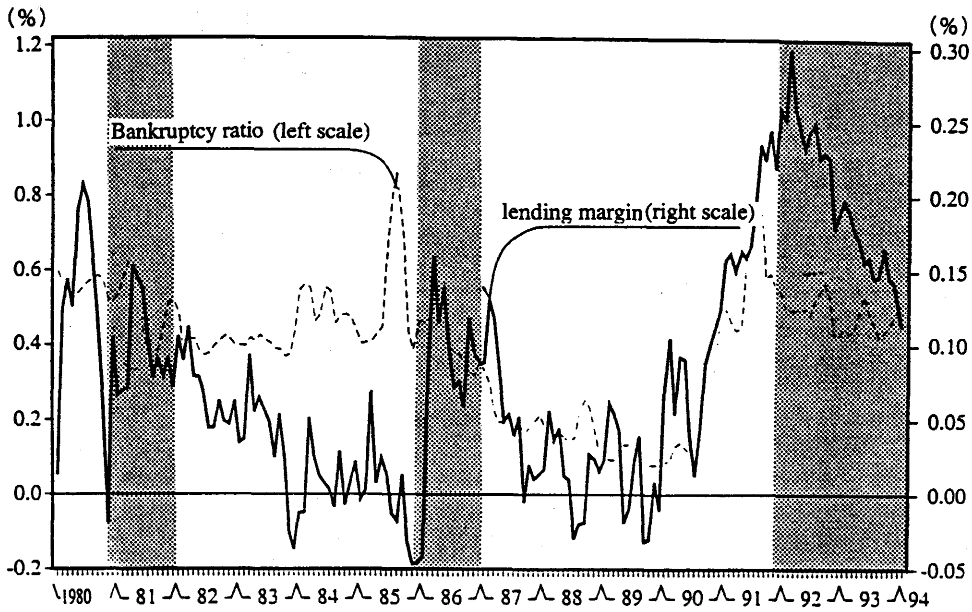
Next, we will look at the lending margin which is thought to be closely related to bank lending attitude. Figure 5A plots the lending margin and ex post ratio of bankruptcy to the loans outstanding of all banks. This figure shows that the lending margin on average has been fluctuating almost in parallel with the ex post ratio of bankruptcy since around 1985. From this co-movement, we can interpret that as default risk rises, banks demand more risk premium on loans. However, we can find that since 1991 the lending margin has widened much more than it did in 1986-87 when the rapid appreciation of the yen after the Plaza Accord led to a sharp slowdown in the Japanese economy. In addition, because in the same period the lending margin has widened more than the increase in the ex post ratio of bankruptcy (Figure 5B),[6] there is the possibility that factors other than default risk , for example, decline in bank risk taking ability, play an important role.[7]

[6] On this point, refer to Okina and Sakuraba (1994).

[7] The Economic Planning Agency (1994) has a similar point of view.

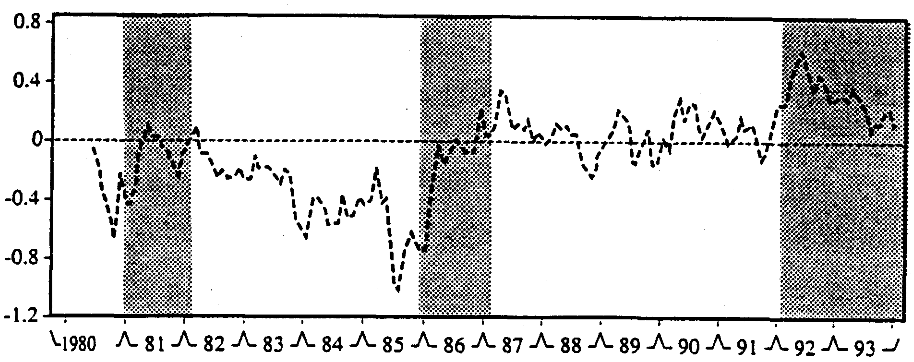
(Figure 5) Movement of the Lending Margin

A. Relation between the lending Margin and ex post bankruptcy ratio



(Notes) 1. lending margin = average contracted interest rates on new loans and discounts - funding cost (including personnel and non-personnel expenses)
2. bankruptcy ratio = amounts of bankruptcies / loans outstanding of all banks
3. Shaded areas indicate period of declining call rate.

B. Estimation error in regressing the lending margin on the bankruptcy ratio



(Notes) Estimated equation : lending margin = -0.264 + 5.15* bankruptcy ratio
(-0.44) (4.35)
(Sample period : July 1980-November 1993 The figures in ( ) denote t value)

(Source) *Economic Statistics Monthly*, Research and Statistics Department, Bank of Japan, *Analysis of Financial Statements of All Banks*, Federation of Bankers Association of Japan, *Bankruptcy Monthly Report*, Tokyo Business Credit Research

III. Overview of Previous Empirical Analyses

Recently, concerning the relationship between the bank lending growth and the share of non-performing loans to total loans (or the capital/asset ratio [BIS standard]), an increasing number of empirical studies has been conducted in Japan, as well as in the U.S. In this section, we briefly review some of the important ones, identify their shortcomings, and discuss the points to be improved in this paper.

A. Research in the U.S.

First of all, we must look at Bernanke and Lown (1991) as a forerunner on this issue. Their work is the first example to deal with the phenomenon called "credit crunch" in the 1980s. It analyzes the relationship between the bank lending growth and the capital/asset ratio showing that the former is negatively correlated with the latter. Following this, Berger and Udell (1992,1993) extensively analyze roles played by the stickiness of loan rates and collateral, keeping in mind the theory of equilibrium credit rationing shown by Stiglitz and Weiss (1981).[8] From these studies, they draw the conclusion that the existence of equilibrium credit rationing did not play a significant role in the macroeconomic context.

In addition, Berger and Udell (1994) conduct comprehensive research on the relationship between the bank lending growth and the capital/asset ratio taking into account the influence of principal macroeconomic variables including GNP growth, unemployment rate, and scale differences of banks.[9] Their results clarify that the capital/asset ratio regulation was not the main cause for the slowdown in bank lending.

Kliesen and Tatom (1992) conduct research from a different viewpoint. They try to test the hypothesis that the decline in inventory investment is a structural cause behind the decline in bank lending and partly verify that there is a Granger-sense causality between these two variables.

However, we must pay particular attention to the fact that all such research is based on the estimation of reduced-form equations. In fact, there are few studies based on a structural equations model. King (1986) is one of the few examples. For the purpose of verifying the existence of equilibrium credit rationing, he uses a structural-form model consisting of loan demand and supply functions.[10] But we can point out as

[8] For further details, see Section 4.

[9] They addjust scale differences using dummy variables.

[10] King (1986) puts the following hypothesis. If adverse selection (and the screening function of loan rates) exists due to asymmetric information in the loan market and the loan supply function is estimated in a linear form, the significance level of the loan rate parameter is low. From estimation

shortcomings the fact that the sample period covers only the 1970s and the theoretical consideration is insufficient with respect to the specification of the loan supply function.

B. Research in Japan

Stimulated by research in the U.S., various analyses have been conducted in Japan regarding the slowdown in bank lending.[11] Among them, Okina and Sakuraba (1994), Yoshikawa, Eto, and Ike (1994), Ito and Sasaki (1995), and Matsui(1995) are the leading examples in which similar methods to those of Bernanke and Lown (1991) and Berger and Udell (1992,1993) are employed. And Ariga et al. (1994) place emphasis on the structural aspects such as the diversification of corporate funding routes and diminishing weight of the loan market. In the following these papers are reviewed in some detail.

Okina and Sakuraba (1994) find that the lending margin is negatively correlated with the capital/asset ratio and that there exists a significant positive correlation between the bank lending growth and the capital-asset ratio by cross-section analysis.[12]

Yoshikawa, Eto, and Ike (1994) analyze the relationship between the bank lending growth and the share of bad loans to total loans only for such categories as small firms, real estate, manufacturing, and construction industries. According to their estimation results, as a whole, they cannot find any significant negative correlation between these variables. However, if banks are divided into some categories, as far as trust banks are concerned, they find the possibility that the share of bad loans has a significant negative effect on lending growth.

Next, Ito and Sasaki (1995) examine how capital standards, the so called Basle Accord, influence Japanese bank lending behavior. Their empirical findings are consistent with a view that banks with lower capital/asset ratio tend to issue more subordinated debt and to extend less loans[13].

Moreover, Matsui (1995) examines the relationship between the ratio of investment to existing capital stock and the ratio of land value held by each firm to loans outstanding using the panel data consisting of financial statements by firms. And he finds that after 1990, in some industries the decline in collateral value cause the

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results using switching regression, he concludes that adverse selection did not exist in the U.S. loan market in the 1970s.

[11] Actually there are many earlier papers concerning bank lending behavior, but most concern the price mechanism of loan rate using a dynamic disequilibrium model. For reference, see Asako and Uchino (1987) and Ito and Ueda (1982).

[12] They analyze city banks, trust banks, and long-term credit banks.

[13] The same categories as Okina and Sakuraba (1994) are analyzed in the paper.

slowdown in bank lending, resulting in sluggish investment.

On the other hand, Ariga et al. (1994) examine the relationship between the bank lending growth and the rate of return on equity using panel data. This work, contrary to the above-mentioned examples, does not intend to verify the cause of the recent slowdown in bank lending directly. Rather, they deal with more structural aspects like the changing route of corporate funding. From the results of empirical analyses, it is shown that firms whose rates of return on equity are relatively low and which fluctuate a lot are obliged to depend upon bank loans because of their limited access to the capital market due to their low creditworthiness. Therefore, they conclude it is highly probable that in Japanese loan market there exists an adverse selection phenomenon where high quality borrowers withdraw from the loan market and only high default risk borrowers remain.

It is thought that all such previous studies have an advantage over earlier studies in that they pay particular attention to empirical methods including the use of cross-sectional or panel data. But, they all lack reliable theoretical grounds in specifying loan supply functions.

Compared with these studies, Kuroda and Kaneko (1985) have a firm theoretical background in specifying the loan supply function. They treat loans as the output of banks and particularly examine the relationship between production scale and cost in the banking industry based on the rational behavior of banks under the existence of default risk. They find that the partial-equilibrium loan supply curve for large firms bends backward to the left when the loan rate rises above a certain level. Their model has the most reliable theoretical and empirical background. But, there is room for further sophistication in that demand side factors are not considered at all.[14]

In this paper, we attempt to bridge the gap between the theoretical background and appropriate empirical method, which is not found in the above studies. Specifically, we try to estimate simultaneously both loan demand and supply functions based on the switching regression model using panel data with a view to analyzing the recent bank lending behavior from both the demand and supply sides.

[14] The possibility that they estimate the loan supply function using the sample that actually exist on the demand curve instead of supply curve cannot be denied.

VI. Theoretical Framework

A. Basic model

Stiglitz and Weiss (1981) devised the following basic model[15] and proved that as the loan rate rises, the expected return on bank lending tends to diminish. The essence of this model lies in the existence of asymmetric information between lenders and borrowers in the sense that banks cannot completely know the quality of borrowers without any cost.[16]

The basic setting of the model is as follows. The variables determining loan conditions are the loan rate r_L and the collateral ratio *Collat* (the ratio of the secured portion to total loans). In this setting, the owner of a project which is financed by loans from a bank will pay back $1+r_L$ to the bank per unit of borrowed funds if the project succeeds, and the value of collateral Co will be seized by the bank if the project fails.

We define (i) the loan demand function as a decreasing function of the loan rate and (ii) the average default probability θ as an increasing function of the loan rate and other variables showing the degree of corporate financial conditions.[17] Here it is assumed that the loan rate gives out the signal concerning the quality of borrowers[18].

The expected rate of return on bank lending ρ is defined as the expected return on bank lending $(1-\theta)r_L$ minus the expected loss$\theta(1-Collat)$ which will not be secured by collateral. Although ρ initially rises with r_L, in the meantime, because borrowers with low default risk exit from the loan market together with the rise in r_L, the portion of high default risk borrowers becomes substantial. Therefore, ρ becomes a decreasing function of r_L (on this point, see Figure 6). In this case, it is said that an adverse selection phenomenon exists and the loan rate functions as a screening device.

A Bank trying to maximize the expected profit effects out lending at the point where marginal revenue equals marginal cost. Marginal cost consists of funding cost and physical expenses. Therefore, in the ordinary case where marginal cost increases with lending size, we can draw a loan supply curve as in Figure 7. (r_L^*, L^*) in Figure 7 is the optimal combination of both loan rate and loans amount. And, the collateral ratio and change in corporate financial conditions not only shift the supply curve inward or

[15] For details on the derivation of the theoretical model, see Appendix 1.

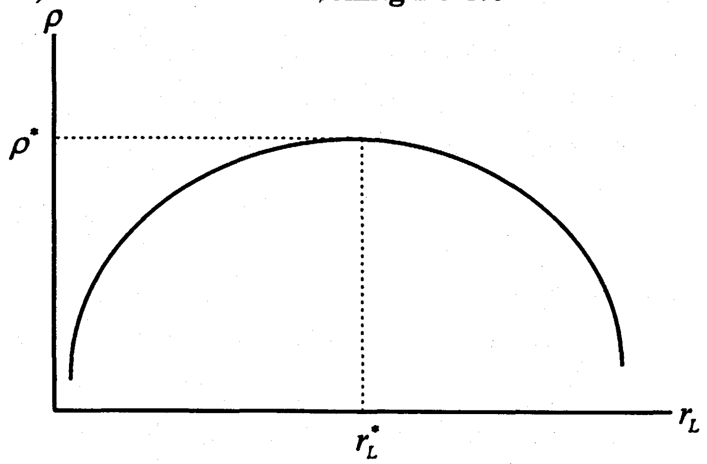
[16] Banks are obliged to bear the following costs: (i) in advance they do not have precise information about risk attaching to borrowers' projects; (ii)they need ex post surveillance because borrowers could use funds for other purposes than originally ststed.

[17] In this paper, the ratio of interest paid by firms to cash flow and the share of non-performing loans to total loans are used as proxy variables.

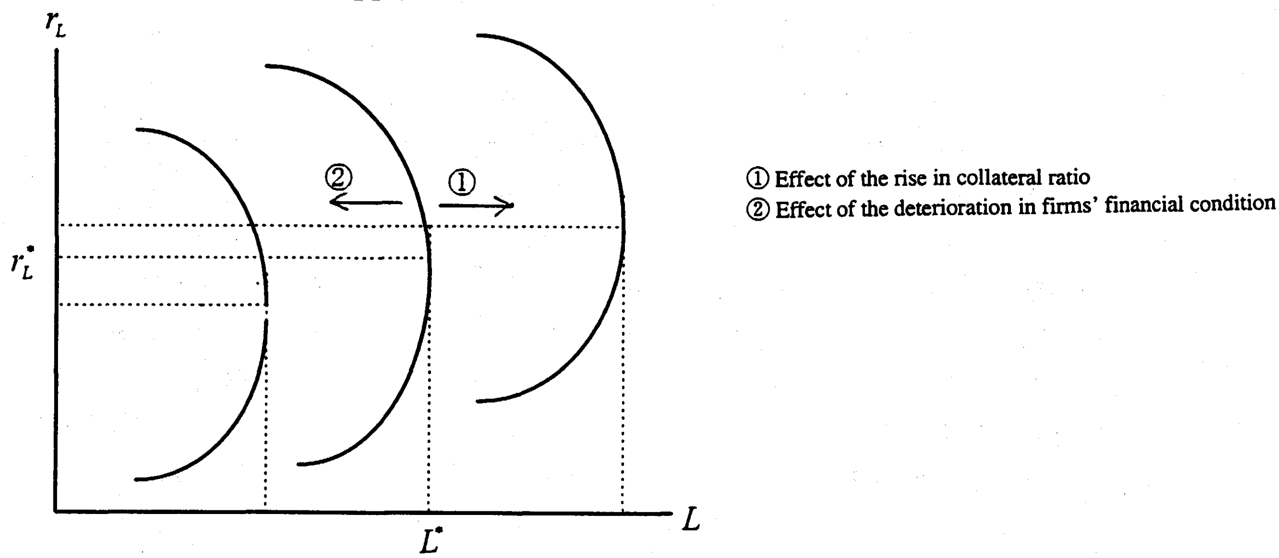
[18] In other words, the higher the loan rate offered by firm is, the lower the quality of the borrower.

outward, but also influence (r_L^*, L^*) by changing the shape of the supply curve[19].

(Figure 6) Loan Rate as a Screening Device



(Figure 7) Shape of the Loan Supply Curve and its Shift



B. Model used in this paper

The basic model explained above implicitly assumes that the loan market is constantly in a state of excess demand and that banks always can choose their optimal combinations of loan rates and loan amounts (r_L^*, L^*) by judging borrower quality from the loan rate accepted by borrowers.[20] From a more realistic point of view, however, it may be natural that the loan market should not be in a constant state of excess demand[21]

[19] On this point, see equation (A-13) and (A-14) in Appendix 1.
[20] Credit rationing through this mechanism is termed equilibrium credit rationing.
[21] As for factors which weaken excess demand, we can point out structural factors such as increase in funding through the capital market, as well as cyclical factors.

and banks cannot necessarily choose borrowers unilaterally.

From these perspectives, in this paper we assume that the observed combinations of loan rates and loan amounts are determined on the short side between loan demand and supply. Although loan rates can coincide with optimal rates for banks, banks cannot choose optimal combinations of loan rates and loan amounts.[22]

Figure 8 illustrates the reasoning behind the determination of loan rates and loan amounts, namely that, corresponding to loan rates given exogeneously to banks,[23] loan amounts are determined on the short side between loan demand and supply curves. For example, Bank A is given loan rate r_A exogenously so that observed loan amounts lie on the demand curve because at that loan rate level loan demand is less than loan supply. On the other hand, for Bank B with loan rate r_B, the observed loan amounts of loans lie on the supply curve.

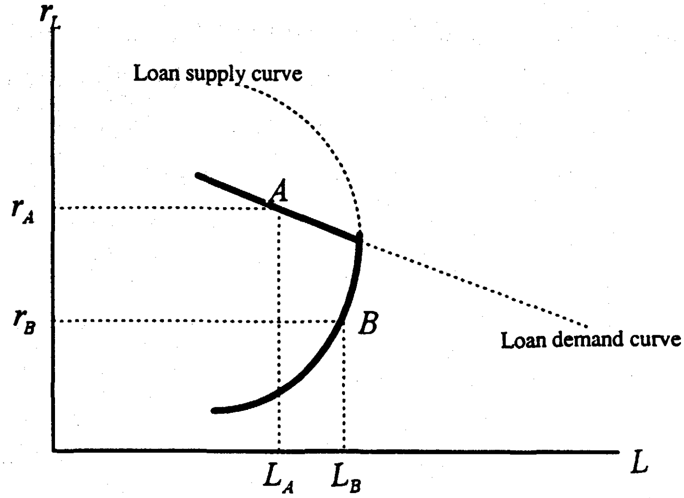
In addition, in this context, we can interpret widening lending margin, which is thought to be one of the noteworthy characteristics mentioned in Section II,as follows. Increased bankruptcies and higher default risk on the part of borrowers due to the prolonged recession pushed the loan supply curve inward and, as a result, banks require higher risk premium from borrowers. The higher risk premium may force firms which previously took risk-averse action to look toward high-risk, high-return type investment projects.[24]

[22] In other words, banks do not have any market power to control their loan rates freely.

[23] For the sake of simplicity, we assume that loan rates are given exogenously to banks. Even though we assume that loan rates are determined based on the balance of bargaining power between lenders and borrowers, it does not alter the essence of this paper's argument.

[24] This effect is called the incentive effect. It shows that moral hazard occurs on the side of borrowers.

(Figure 8) Short Side Principle and Observed Combinations of Loan Rates and Loan Amounts



(Note) On the portion depicted in boldface there exist the observed combinations of the loan rates and loan amounts.

V. Empirical Studies

In order to test the above-mentioned hypotheses, we divide empirical studies into the following:

(i) a simultaneous estimation of structural loan demand and supply functions,

and (ii) reduced-form estimation of lending margin and loan rate functions.

A. Analysis of bank lending behavior by estimating a structural model

1. Specification of demand and supply functions

First, after specifying a loan supply function based on the theoretical foundation explained in the previous section, we estimate supply and demand functions simultaneously[25] using panel data of individual banks. Second, from the estimation results, we simulate the relative positions of both loan supply and demand curves over time and also calculate the probability that the loan market is in a state of excess demand. The loan supply function is specified as a quadratic form[26] in the following

[25] As for estimation method, we use a switching regression model on the basis of the short-side principle. We do not effect sample division. For more details, see Appendix 2.

[26] As shown later (refer to Table 1 and 2), because the significance level of the interactive terms between loan rate and exogenous variables are generally very low, it becomes clear that exogenous variables have effects that simply shift the loan supply curve inward or outward. But here, we show the general form of the loan supply function including interactive terms. Besides, we omit call rate which is thought of as a policy instrument of the Bank of Japan since it has a wrong sign.

manner;

$$\left(\frac{\Delta L}{L}\right)_{it}^{S} = a_0 + a_1 r_{Lit} + a_2 r_{Lit}^2 + a_3 r_{Lit}\left(\frac{Int}{Cash}\right)_{t-1} + a_4 r_{Lit} Sinyo_{it-1} + a_5 r_{Lit} Bad_{it-1} + a_6\left(\frac{Int}{Cash}\right)_{t-1}$$
$$+ a_7 Sinyo_{it-1} + a_8 Bad_{it-1} + a_9\left(\frac{\Delta D}{D}\right)_{it-1} + a_{10} TD_i + a_{11} CD_i + \varepsilon_{it}^{S} \quad (1)$$

where $\frac{Int}{Cash}$ [27] is the ratio of interest paid by firms to cash flow, Bad is the share of bad loans to total loans,[28] $Sinyo$ [29] is the share of unsecured loans to total loans, and TD (CD) [30] is a dummy variable which is equal to 1 in the case of city banks (regional banks), otherwise it is equal to 0 (ε_{it}^{S} is an error term). Here, required parameter conditions[31] are $a_1 > 0, a_2 < 0, a_3 < 0, a_4 > 0,\ a_5 < 0,\ a_6 < 0,\ a_7 < 0,\ a_8 < 0,\ a_9 > 0$.

If the loan rate indeed functions as a screening device associated with asymmetric information in the loan market, then the elasticity of loan supply to loan rate gradually diminishes gradually with a rise in the loan rate and eventually falls below zero. The interactive terms between loan rate r_L and exogenous variables such as $Sinyo$, $\frac{Int}{Cash}$ and Bad are anticipated to effect the optimal combinations of the loan rates and the loan amounts, as well as shift the loan supply curve inward or outward.

In addition, we compare the performance of another kind of loan supply function specified as a linear function with equation (1); this loan supply function corresponds to the specification where the quadratic term of loan rate $a_2 r_{Lit}^2$ is omitted from equation (1).

On the other hand, the loan demand function is specified as[32]

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[27] As for the ratio of interest paid by firms to cash flow, only aggregate (macro) data can be obtained.

[28] In Japan, since we don't have comprehensive data equivalent to non-performing loans in the U.S. (precisely speaking, since March 1993, city banks, long-term credit banks, and trust banks have publicly announced loans to insolvent borrowers and arrears.), we define the sum of transfers to reserves for possible loan losses and written-off claims as bad loans.

[29] $Collat$ in the last section corresponds to $(1 - Sinyo)/100$ ($Sinyo$ is denominated in %).

[30] These dummy variables are employed with a view to adjusting the differences attributed to bank category.

[31] a_0, a_{10}, a_{11} cannot be predetermined.

[32] Because, generally speaking, it is thought that it takes one year or so from the decision to effect investment until actual borrowing, a year lag in the loan rate is added as an explanatory variable.

$$\left(\frac{\Delta L}{L}\right)_{it}^{D} = b_0 + b_1 r_{Lit} + b_2 r_{Lit-1} + b_3 DI_{it-1} + \varepsilon_{it}^{D} \quad (2)$$

where DI[33] is the diffusion index of business condition sentiment in the head office locals of each bank. Required parameter conditions are $b_1 < 0, b_2 < 0, b_3 > 0$[34].

2. Estimation results

Estimation is conducted using the data set obtained from the financial statements of all banks[35] and some macroeconomic indicators[36]. The full sample period is FY1982-92. For technical reasons associated with data processing and lagged variables, we divide the full sample into three sub-periods (FY1984-86, FY1987-89, FY1990-92) and conduct estimations with and without interactive terms of loan supply function for the sake of comparison.

According to the estimation results (Table 2 and 3), only during one sub-period (FY1990-92) do both the loan supply function specified in a quadratic form (without interactive terms) and demand function fit fairly well. All signs are correct and all parameters are also statistically significant. On the other hand, when the loan supply function is specified in a linear form, only during one period (FY1990-92) does fit well and almost all parameters have correct signs, but the significance level of the loan rate parameter is much lower than that in the case of the quadratic specification. These results possibly evidence the screening function of loan rates.

Hence, we look further at estimation results in the case of the quadratic specification without interactive terms. During the sub-period FY1990-92, in general, the parameters of exogenous variables such as the ratio of interest paid by firms to cash flow, the share of bad loans and also unsecured loans are more significant than those during other sub-periods. From these results, we can infer that in the recent recession, because future financial conditions for borrowers became more uncertain, the lending attitude of banks became more strict and they paid particular attention to the role of collateral as well as the screening function of loan rates.

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[33] The source for the DI is *Short-term Economic Survey of Enterprises in Japan*, Bank of Japan.

[34] As for b_0, the sign cannot be predetermined since it is a constant term.

[35] Usually, all banks consist of city banks, regional banks, regional II banks, long-term banks and trust banks. But we exclude long-term banks and trust banks because they have different balance sheet structures from other categories. We also exclude the Bank of Tokyo from city banks for the same reason. Additionally we omit three regional II banks whose scale is much smaller than others. In total, the data set consists of 136 banks (10 city banks, 64 regional banks, 62 regional II banks). Exclusion of the banks mentioned does not greatly influence the estimation results.

[36] For details of data used in this paper, see Appendix 3 (Data Appendix).

Next, we turn to the estimation results of loan demand functions. The DI of business condition sentiment adopted as a shift variable has a correct sign during each sub-period and its significance level is very high. The DI deteriorated all through FY1990-92 so demand-side factors contributed to the decline in lending growth considerably.

Figures 9 and 10 plot the shifts of both supply and demand curves simulated using the estimated results during FY1990-92. From these, it can been seen that the demand curve consistently shifted inward due to the deterioration in the DI so that the demand-side factor greately contributed to the sluggish lending growth. On the other hand, the supply curve shifted inward because of the rise in both the share of bad loans and unsecured loans during FY1990-91. However, during FY1991-92 period, it shifted back owing to the improvement in the ratio of interest paid by firms to cash flow. From these simulated results, it can tentatively be concluded that the main cause of the sluggish bank lending after bursting of the bubble economy was the consistent decline in loan demand associated with the prolonged and severe recession. But we must bear in mind that our simulated results on the relative positions of supply and demand curves over time are obtained on the premise that each bank is valued at the same weight. Table 1 shows the degree to which combinations of loan rates and lending growth are in a state of excess demand by bank category during FY1990-92. According to the results, as for regional and regional II banks, the probability has declined a lot. To the contrary, for city banks whose weight of loans outstanding is large, the degree of excess demand has risen . Therefore, when we look at the loan market as a whole after adjustment for the weight of loans outstanding by category, the probability that it is in a state of excess demand in FY1992 is almost the same as that FY1990.

(Table 1) The Probability that Combinations of Loan rates and the Estimated Lending Growth are in a State of Excess Demand

	city bank	regional bank		regional bank II	average of three categories	
		average	top 10 banks		weighted average	arithmetic average
FY1990	72.376(0.605)	93.599(0.285)	91.213(0.113)	80.122(0.110)	79.085(1.000)	82.032(1.000)
FY1992	84.697(0.598)	78.574(0.293)	82.630(0.114)	35.446(0.109)	77.849(1.000)	66.239(1.000)

(Notes) 1. ( )indicates the weight of loans outstanding by category.

2. Top 10 banks of regional banks are Yokohama bank, Chiba bank, Hokuriku bank, Shizuoka bank, Joyo bank, Ashikaga bank, Fukuoka bank, Hiroshima bank, Hachijuni bank, Gunma bank.

(Table 2-A) Estimation Results of Loan Supply and Demand Functions

[Specification of Loan Supply Function (quadratic form)]

$$\left(\frac{\Delta L}{L}\right)^{s}_{it} = a_0 + a_1 r_{Lit} + a_2 r^2_{Lit} + a_3 r_{Lit}\left(\frac{Int}{Cash}\right)_{t-1} + a_4 r_{Lit} Sinyo_{it-1} + a_5 r_{Lit} Bad_{it-1} + a_6\left(\frac{Int}{Cash}\right)_{t-1}$$
$$+ a_7 Sinyo_{it-1} + a_8 Bad_{it-1} + a_9\left(\frac{\Delta D}{D}\right)_{it-1} + a_{10} TD_i + a_{11} CD_i + \varepsilon^{s}_{it}$$

	FY1984-86		FY1987-89		FY1990-92	
parameter	with interaction	without interaction	with interaction	without interaction	with interaction	without interaction
(Loan Supply Function)						
a0	-80.813	-62.950		58.495	2.924	-40.825
	(-0.196)	(-1.827)*		(2.361)**	(0.003)	(-2.720)***
a1	-0.425	-2.942		-15.922	6.595	17.068
	(-0.007)	(-0.308)		(-1.684)*	(0.030)	(3.768)***
a2	0.133	-0.227		1.423	-0.723	-1.336
	(0.041)	(-0.303)		(1.538)	(-0.071)	(-3.818)***
a3	-0.135	——		——	0.086	——
	(-0.069)	(——)		(——)	(0.023)	(——)
a4	0.002	——		——	0.037	——
	(0.006)	(——)		(——)	(0.034)	(——)
a5	4.670	——		——	3.023	——
	(0.449)	(——)		(——)	(0.041)	(——)
a6	3.479	2.962		-0.246	-0.731	-0.163
	(0.262)	(6.314)***		(-2.101)**	(-0.027)	(-2.543)**
a7	0.340	0.016		-0.015	-0.024	-0.057
	(0.201)	(0.629)		(-0.953)	(-0.004)	(-3.390)***
a8	-32.374	-3.942		-2.307	-24.510	-6.114
	(-0.480)	(-2.001)**		(-3.326)***	(-0.056)	(-2.721)***
a9	0.271	0.818		0.475	0.087	0.054
	(1.036)	(8.823)***		(6.346)***	(0.108)	(2.446)**
a10	1.093	7.508		-0.252	0.104	-0.593
	(0.011)	(1.410)		(-0.280)	(0.002)	(-0.819)
a11	-1.826	-1.915		-1.516	-0.623	-1.905
	(-0.836)	(-2.726)***		(-2.391)**	(-0.056)	(-4.625)***
(Loan Demand Function)						
b0	8.873	-26.343		40.253	-4.213	13.098
	(1.594)	(-3.004)***		(3.006)***	(-0.836)	(0.843)
b1	-5.691	-7.031		-6.106	-1.552	-5.356
	(-7.540)***	(-6.584)***		(-1.807)*	(-3.028)***	(-2.713)***
b2	5.570	11.951		-0.404	-0.646	-3.014
	(5.442)***	(7.478)***		(-0.180)	(-2.403)**	(-1.944)*
b3	-6.914	4.077		23.257	36.195	79.463
	(-1.168)	(0.510)		(2.368)**	(3.738)***	(2.412)**
LOG LIKELIHOO	-1116.995	-1033.057		-1044.481	-1016.586	-980.092
RHO	-0.001	-0.322		0.181	-0.001	0.923
	(-0.001)	(-2.062)**		(0.266)	(-0.000)	(4.642)***
σ_S	3.352	3.585		2.928	2.893	2.554
	(2.441)**	(13.767)***		(13.026)***	(0.171)	(25.757)***
σ_D	3.776	3.806		5.762	2.927	3.160
	(22.905)***	(11.974)***		(4.519)***	(23.530)***	(10.012)***

(Notes) 1. Figures in ( ) denote t-values. *:significant at 10% level. **:significant at 5 % level. ***:significant at 1 % level.
2. In the case where convergence cannot be achieved after iterations, oblique linesare drawn.
3. RHO is the correlation coefficient between two functions. σ_S and σ_D are variance of error terms.
4. Loan demand function is the same specification as equation(2) on page 15.

(Table 2-B) Estimation Results of Loan Supply and Demand Functions

[Specification of Loan Supply Function (linear form)]

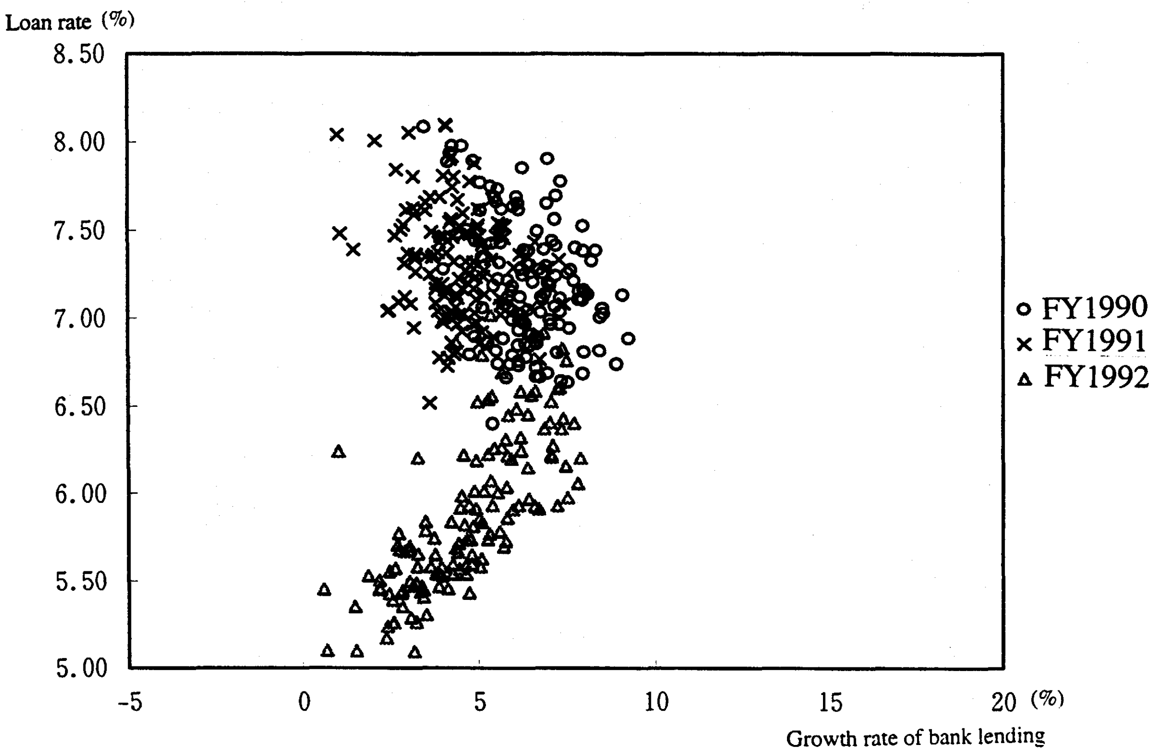
$$\left(\frac{\Delta L}{L}\right)^{s}_{it} = a_0 + a_1 r_{Lit} + a_3 r_{Lit}\left(\frac{Int}{Cash}\right)_{t-1} + a_4 r_{Lit} Sinyo_{it-1} + a_5 r_{Lit} Bad_{it-1} + a_6\left(\frac{Int}{Cash}\right)_{t-1}$$
$$+ a_7 Sinyo_{it-1} + a_8 Bad_{it-1} + a_9\left(\frac{\Delta D}{D}\right)_{it-1} + a_{10} TD_i + a_{11} CD_i + \varepsilon^{s}_{it}$$

	Fy1984-86		FY1987-89		FY1990-92	
parameter	with interaction	without interaction	with interaction	without interaction	with interaction	without interaction
(Loan Supply Function)						
a0		-52.996 (-4.037)***		26.604 (4.499)***	64.003 (0.069)**	8.236 (1.988)**
a1		-5.832 (-7.771)***		-2.198 (-3.412)***	-7.094 (-0.054)	0.541 (1.438)
a2		—— (——)		—— (——)	—— (——)	—— (——)
a3		—— (——)		—— (——)	0.206 (0.048)	—— (——)
a4		—— (——)		—— (——)	0.049 (0.030)	—— (——)
a5		—— (——)		—— (——)	3.461 (0.033)	—— (——)
a6		2.938 (6.353)***		-0.272 (-2.616)***	-1.595 (-0.052)	-0.114 (-1.281)
a7		0.016 (0.630)		-0.011 (-0.641)	-0.069 (-0.007)	-0.058 (-2.806)***
a8		-3.944 (-2.024)**		-3.729 (-7.050)***	-27.344 (-0.042)	-5.001 (-1.982)**
a9		0.814 (8.903)***		0.496 (6.573)***	0.085 (0.065)	0.115 (3.391)***
a10		7.339 (1.353)		1.220 (0.923)	-0.166 (-0.001)	-1.398 (-1.637)
a11		-1.904 (-2.777)***		-1.809 (-2.719)***	-0.626 (-0.043)	-1.936 (-3.160)***
(Loan Demand Function)						
b0		-26.775 (-3.046)***		1.915 (0.152)	-4.213 (-0.838)	-19.215 (-1.174)
b1		-6.953 (-6.705)***		-5.894 (-2.297)**	-1.550 (-3.116)***	-8.263 (2.900)***
b2		11.956 (7.518)***		5.009 (1.685)	-0.647 (-2.416)**	0.453 (0.518)
b3		3.934 (0.494)		35.012 (2.816)***	36.195 (3.784)***	123.680 (2.706)***
LOG LIKLIHOOD		-1033.100		-1046.565	-1016.664	-980.799
RHO		-0.322 (-2.074)**		0.137 (0.331)	-0.001 (-0.000)	-0.1774 (-0.626)
σ_S		3.580 (13.869)***		3.293 (14.438)***	2.907 (0.107)	2.590 (11.125)***
σ_D		3.807 (11.969)***		4.078 (5.395)***	2.927 (24.237)***	4.245 (6.852)***

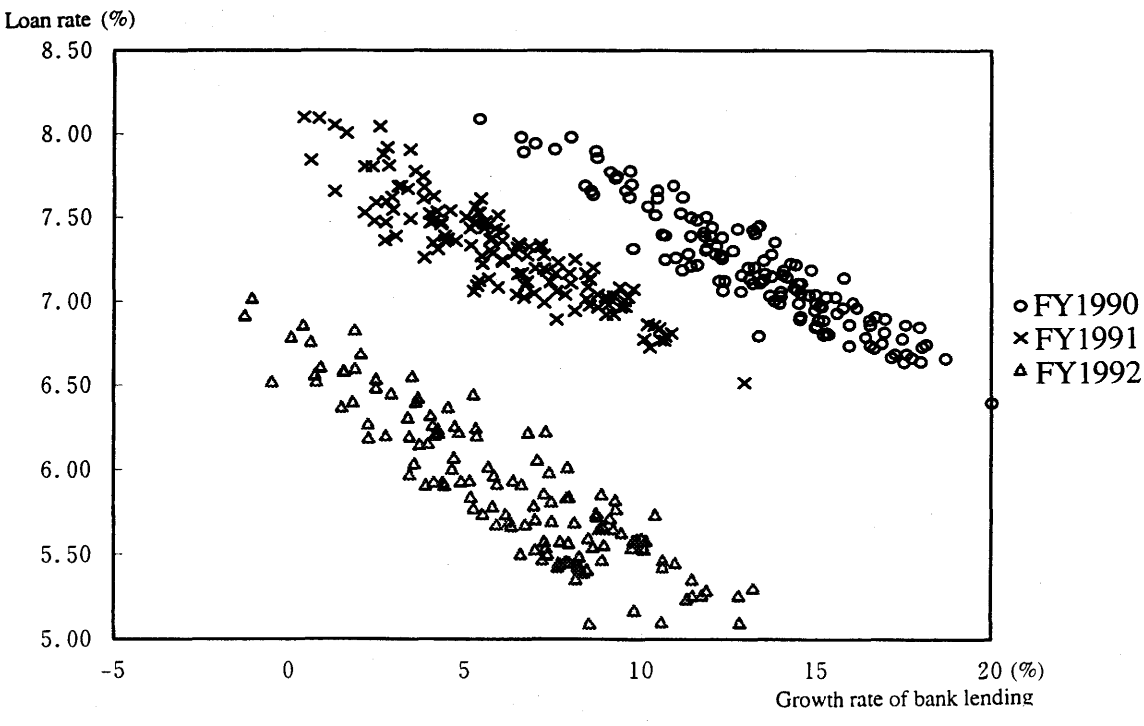
(Notes) 1. Figures in ( ) denote t-values. *:significant at 10% level. **:significant at 5 % level. ***:significant at 1 % level.
2. In the case where convergence cannot be achieved after iterations, oblique lines are drawn.
3. RHO is the correlation coefficient between two functions. σ_S and σ_D are variance of error terms.
4. Loan demand function is the same specification as equation(2) on page 15.

(Figure 9) Estimated Loan Supply and Demand Curves

A. Loan supply curve



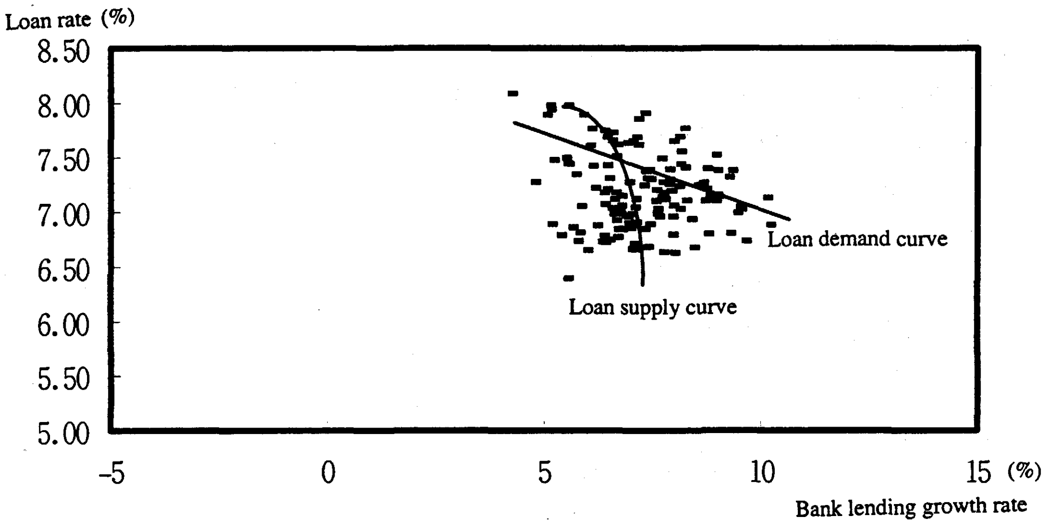
B. Loan demand curve



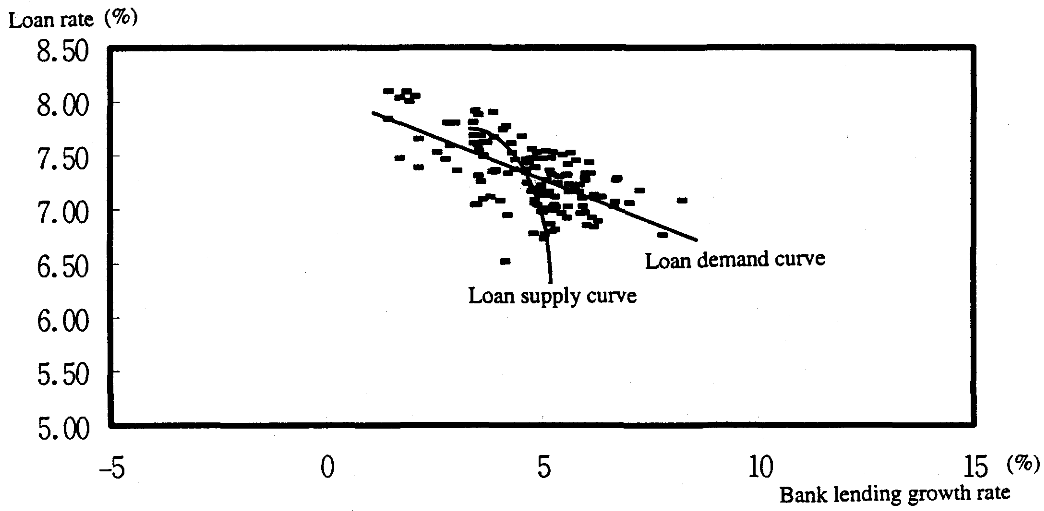
(Note) Both loan supply and demand curves are obtained on the premise that full sample lie on the each curve by omitting the short-side principle.

(Figure 10) Plots of Estimated Value and Images of Loan Demand and Supply Curves

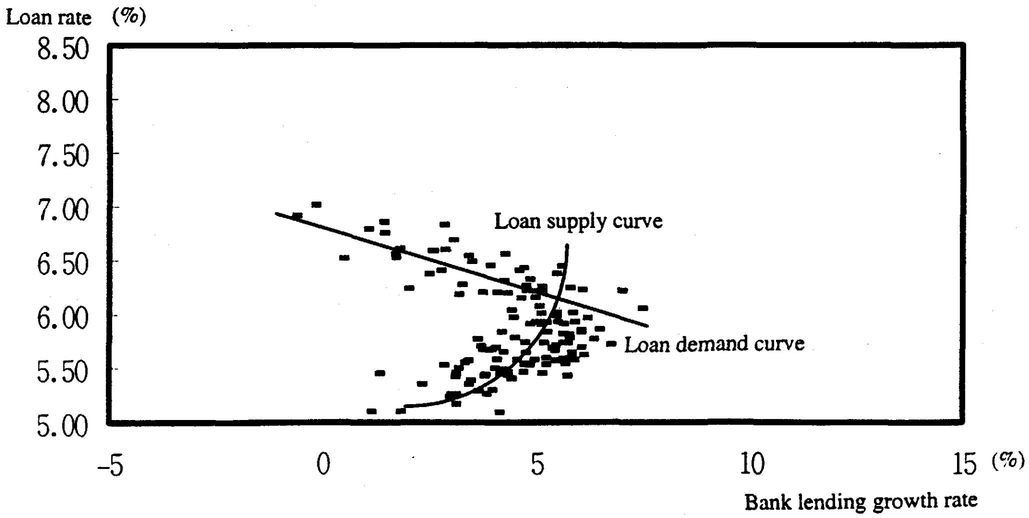
A. FY1990



B.FY1991



C. FY1992



B. Estimation of the Lending Margin and Loan Rate Functions

1. Specification

In the above structural-form analysis, it is assumed that loan rates are given to banks exogenously so that we cannot give any reasons why the lending margin has widened in the recent recession. Therefore, in order to complement this analysis, we try to estimate both the reduced-form lending margin and loan rate functions on the assumption that the combinations of loan rates and lending growth are distributed in the neighborhood of the equilibrium point of loan supply and demand curves. Both functions are specified as follows:

$$Margin_{it} = c_0 + c_1 DI_{it-1} + c_2\left(\frac{Int}{Cash}\right)_{t-1} + c_3 Sinyo_{it-1} + c_4 Bad_{it-1} + \varepsilon^M_{it} \quad (3)$$

$$r_{Lit} = d_0 + d_1 Fund_{it} + d_2 DI_{it-1} + d_3\left(\frac{Int}{Cash}\right)_{t-1} + d_4 Sinyo_{it-1} + d_5 Bad_{it-1} + \varepsilon^r_{it}\ . \quad (4)$$

Here $Margin$ is defined as loan rate r_L minus funding cost $Fund$. Expected signs are $c_1 > 0, c_2 > 0, c_3 > 0, c_4 > 0$ for equation (3), and $d_1 > 0$, $d_2 > 0$, $d_3 > 0$, $d_4 > 0, d_5 > 0$ for equation (4)[37].

2. Estimation results (Table 3)

Estimation is conducted during FY1990-92 using the fixed effect model.[38] According to the estimation results, the increase in the interest to cash flow ratio significantly raises both the loan rate and lending margin. Also, the share of bad loans raises both of them, although its significance levels are lower than that of the interest to cash flow ratio. The unsecured loan ratio, however, has a wrong sign in each case and the sign of the demand-side factor (DI) is unstable depending on the combination of other variables.

On the other hand, as for the relationship between loan rate and funding cost, because the parameter is almost equal to 1 in each case, it is clear that the loan rate falls almost in parallel with the decline in funding cost.

To sum up, we can conclude that in the recent monetary relaxation period, banks have an incentive to lower loan rates in accordance with the fall in funding cost.

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[37] Since c_0 and d_o are constant terms, their signs cannot be predetermined.

[38] The estimated values using this method are generally called covariance estimators. For futher discussion, for example, see Hatanaka (1991).

However, due to the deterioration in corporate financial conditions and increase in bad loans, they demand a higher risk premium on loans, which has widened the lending margin.

(Table 3A) Estimation Results of the Lending Margin Functions

[Specification]

$$Margin_{it} = c_0 + c_1 DI_{it-1} + c_2 \left(\frac{Int}{Cash}\right)_{t-1} + c_3 Sinyo_{it-1} + c_4 Bad_{it-1} + \varepsilon^M_{it}$$

	FY1990-1992						
c1	0.266 (1.136)	-0.545 (-2.455)**	0.079 (0.372)	0.181 (0.773)	-0.794 (-4.145)***	0.049 (0.228)	-0.655 (-2.959)***
c2	0.020 (7.110)***	―――	0.020 (7.209)***	0.020 (7.153)***	―――	0.021 (7.230)***	―――
c3	-0.096 (-2.734)***	-0.011 (-2.807)***	-0.008 (-2.409)**	―――	-0.009 (-2.431)**	―――	―――
c4	0.248 (-3.389)***	0.307 (2.160)**	―――	0.181 (1.392)	―――	―――	0.233 (1.647)
R-SQ	0.616	0.545	0.611	0.606	0.539	0.605	0.533
F-VALUE	5.688	4.529	5.649	5.542	4.467	5.549	4.393

(Notes) 1. Figures in ( ) denote t-values. *:significant at 10% level. **:significant at 5 % level. ***:significant at 1 % level.
2. Because of the limitation of the space, the constant terms corresponding to each bank are omitted.

(Table 3B) Estimation Results of the Loan rate Functions

[Specification]

$$r_{Lit} = d_0 + d_1 Fund_{it} + d_2 DI_{it-1} + d_3 \left(\frac{Int}{Cash}\right)_{t-1} + d_4 Sinyo_{it-1} + d_5 Bad_{it-1} + \varepsilon^r_{it}$$

	FY1990-1992						
d1	0.922 (20.942)***	1.060 (24.510)***	0.904 (21.691)***	0.915 (20.598)***	1.031 (24.540)***	1.056 (24.114)***	0.905 (21.512)***
d2	1.423 (2.059)**	-1.352 (-2.160)**	1.568 (2.301)**	1.439 (2.060)**	-1.234 (-1.959)*	-1.410 (-2.225)**	1.526 (2.218)**
d3	0.023 (7.202)***	―――	0.023 (7.578)***	0.023 (7.307)***	―――	―――	0.023 (7.578)***
d4	-0.009 (-2.641)***	-0.011 (-2.854)***	-0.008 (-2.445)***	―――	-0.009 (-2.414)**	―――	―――
d5	0.169 (1.228)	0.362 (2.456)**	―――	0.0978 (0.716)	―――	0.283 (1.930)*	―――
R-SQ	0.952	0.943	0.952	0.951	0.942	0.942	0.951
F-VALUE	59.207	49.807	59.510	58.284	49.204	48.813	59.809

(Notes) 1. Figures in ( ) denote t-values. *:significant at 10% level. **:significant at 5 % level. ***:significant at 1 % level.
2. Because of the limitation of the space, the constant terms corresponding to each bank are omitted.

6. Concluding Remarks

According to the estimation results, the following facts have become clear: (i) only during one sub-period (FY1990-92) did the screening function of loan rates associated with asymmetric information exist; (ii) the increasing deterioration of corporate financial conditions (share of bad loans and ratio of unsecured loans) significantly shifted the loan supply curve inward and contributed to the decline in lending growth, together with the inward shift of the demand curve due to sluggish business conditions; (iii) looking at supply and demand state of loan market by bank category, for regional banks, excess demand has diminished. Whereas, for city banks, excess demand has been relatively high compared with other categories; (iv) in recent years, banks have demanded a higher risk premium and expanded the lending margin as default risk has heightened. This is one reason explaining the delay in the effect of cumulative monetary relaxation to date.

But it is also true that we omit some crucial points in this paper, perhaps, the most important being capital standards, the so called Basle Accord. Comprehensive studies taking this matter into consideration will be a future task.

Appendix 1: Derivation of Theoretical Model

In this Appendix, first, we explain theoretical model concerning the relationship between asymmetric information and the function of the loan rate as a screening device (or adverse selection) based on Stiglitz and Weiss (1981). Second, by solving maximization problem of the expected profit, we derive loan supply function.

A. Asymmetric Information and the function of Loan Rate as a Screening Device

Suppose that a bank has identified a group of projects; for each project there is a probability distribution of returns R. Different firms have different probability distribution of returns. It is also assumed that the bank can distinguish projects with different mean returns, but in advance the bank is unable to have precise information on the riskness of each project.[39] For the sake of convenience, we define the distribution of returns as $F(R,\theta)$ and the density function as $f(R,\theta)$, and further assume that the greater θ is, the riskier the project, in the sense that the greater θ corresponds to large variance from the mean of returns. For example, in the case that $\theta_1 > \theta_2$, if

$$\int_0^\infty Rf(R,\theta_1)dR = \int_0^\infty Rf(R,\theta_2)dR \qquad \text{(A-1)}$$

then for $y \geq 0$, following relation holds.

$$\int_0^y F(R,\theta_1)dR \geq \int_0^y F(R,\theta_2)dR \qquad \text{(A-2)}$$

Here if we define the amount of borrowing, the loan rate and collateral as L, r_L, Co respectively, the expected return for the borrower π is

$$\pi = max(R-(1+r_L)L\,;-Co) \qquad \text{(A-3)}$$

and the expected return for the bank can be described as

$$\rho = min(R+Co; L(1+r_L)). \qquad \text{(A-4)}$$

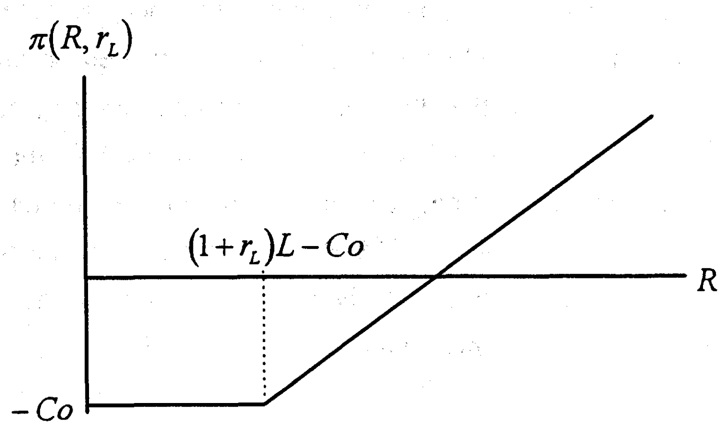
That is, if the borrower cannot perform his or her duty to pay the debt in

[39] This assumption indicates the existence of asymmetric information between lenders and borrowers.

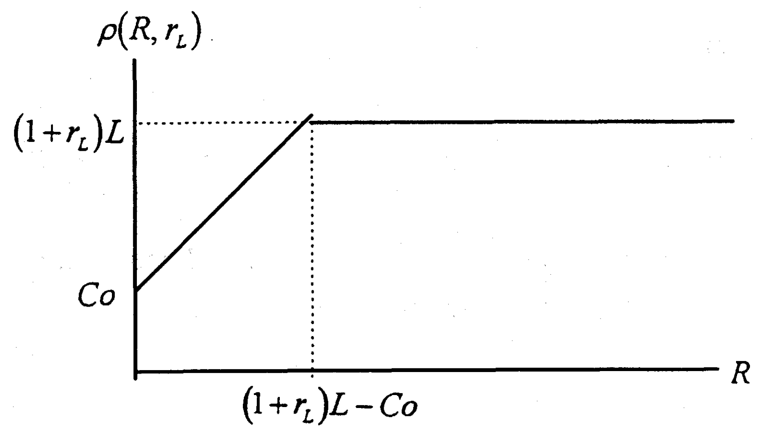
accordance with the contract because of the failure of the project, he or she will be forced to pay the debt from both the return that he or she barely will earn and his or her collateral. At this time, the expected return for the borrower represented by equation (A-3) and the expected return for the bank represented by equation (A-4) can be depicted in Figure A.

(Figure A) Expected Return Curve for a Borrower and a Bank

(i) Expected return curve for a borrower



(ii) Expected return curve for a bank



Here, it is clear that from the above assumptions concerning θ and R, the expected return for borrower rises together with the riskness of the borrower's project. Moreover, if the loan rate r_L is given at a higher level than before, the borrower must raise the expected return of the project by raising θ above a certain level in order to borrow from the bank. Now, we define the critical value of θ as $\hat{\theta}$. The $\hat{\theta}$ for which the expected return is zero must satisfy

$$\Pi\left(r_L,\hat{\theta}\right)=\int_0^{\infty} max\left[R-\left(r_L+1\right)L;-Co\right]dF\left(R,\,\hat{\theta}\right)=0\,. \tag{A-5}$$

By differentiating equation (A-5) with respect to the loan rate r_L, following relation can be obtained.

$$\frac{d\hat{\theta}}{dr_L}=\frac{L\int_{(1+r_L)L-Co}^{\infty} dF\left(R,\hat{\theta}\right)}{\partial\Pi/\partial\hat{\theta}}>0 \tag{A-6}$$

Equation (A-6) shows that as the loan rate r_L rises, the critical value of θ, below which potential borrowers don't apply for loans, increases. These discussions imply that in addition to the direct effect of the rise of loan rate, there exists an indirect, so called adverse selection effect in the opposite direction. In this case, it is said that loan rate has a role of screening borrowers.

B. Derivation of Loan Supply Function in the Case where the Loan Rate Functions as a Screening Device

Based on the above discussion concerning the loan rate as a screening device, we clarify that loan supply function cannot be necessarily the monotone increasing function of the loan rate. That is, as the loan rate rises, the elasticity of loan supply to loan rate diminishes and above a certain point, it turns below zero.

Before preceding, for the sake of simplicity, we define the riskness θ peculiar to the investment project as

$$\theta=\theta\left(\overset{\oplus}{r_L},\overset{\oplus}{X}\right) \tag{A-7}$$

where X is variables showing the deterioration of corporate financial environment such as the ratio of interest paid by firms to cash flow and the share of bad loans to total loans. Equation (A-7) is the simplified version of the description of adverse selection effect that the loan rate provides a signal with regard to the quality of borrowers[40] and the riskness depends upon the deterioration of corporate financial environment.

Next, we define the expected return ratio per unit of bank lending as follows.

[40] The quality of borrowers becomes lower together with the rise of the loan rate.

$$\rho' = (1-\theta)r_L - \theta(1 - Collat) \tag{A-8}$$

where $Collat$ is the share of loans secured by some kind of collateral[41] to total loans. By differentiating equation (A-8) with respect to loan rate r_L, we obtain

$$\frac{\partial \rho'}{\partial r_L} = -(1 + r_L - Collat)\theta_{r_L} + (1-\theta). \tag{A-9}$$

From equation (A-9), it becomes clear that the expected return ratios per unit of bank loans draws the curve depicted in Figure 6 on page 12. Now in order to derive the loan supply function from these relationships, we simplify the bank balance sheet of in the following manner.

$$L + M = (1-k)D \tag{A-10}$$

Here L is the loans outstanding, M is the call loans outstanding[42] and D is the deposits outstanding. From these information, we can express the expected return Φ as follows.

$$\Phi = \{(1-\theta)r_L - \theta(1 - Collat)\}L + r_M M - r_D D - C(L,D) \tag{A-11}$$

where r_M is call rate, r_D is deposit rate and $C(L,D)$ is the cost function which is assumed to depend upon loans and deposits. By substituting equation (A-10) into equation (A-11) and differentiating Φ with respect to L, we obtain the first-order condition[43] for the maximization of the expected returns as below:

41 As for the type of loans secured by collateral, we can list four major types. They are loans secured by real estate and floating mortgages, stocks and bonds, deposits, and third party's guarantee, respectively.

42 $M > 0$ indicates that the bank is in the net loan position and $M < 0$ indicates the net call position.

43 In this paper, for the sake of simplicity, it is assumed that deposits are given exogeously to banks. This assumption corresponds to the case where because the deposit rate is not completely liberalized, deposits are determined by the supplier of deposits like households and firms (for more details, for example, see Tachi[1985]). On the other hand, if we consider the case where banks can determine deposits endogenously (that is, the deposit rate and the amount of deposits are jointly determined at the intersecting point of deposit supply and demand curves), another condition $(1-k)r_M - r_D - C_D = 0$ should be added as the first-order condition.

$$\frac{\partial \Phi}{\partial L} = (1-\theta)r_L - \theta(1-Collat) - r_M - C_L = 0 \qquad \text{(A-12)}^{44}$$

Furthermore, by totally differentiating equation (A-12), we obtain

$$dL = \frac{1}{C_{LL}}\left[\{(1-\theta)-(1-Collat+r_L)\theta_{r_L}\}dr_L + \{-(1-Collat+r_L)\theta_X\}dX + \theta dCollat - dr_M - C_{LD}dD\right].$$

(A-13)

Equation (A-13) clarifies that other things being equal, for the while, the rise of the loan rate gives a bank an incentive to increase loan supply. However, because the rise of the loan rate has the effect forcing potential borrowers with high quality to exit from the loan market, the elasticity of loan supply to the loan rate declines as the loan rate rises. This relationship is drawn in Figure 7 on page 12. For the purpose of determing the signs in equation (A-13), we futher assume $C_{LL} > 0, C_{LD} < 0$[45] concerning the cost function.

Now, the optimal loan rate r_L^* for the bank is expressed as:

$$r_L^* = \frac{\{1-\theta(r_L, X)\}-(1-Collat)\theta_{r_L}}{\theta_{r_L}}. \qquad \text{(A-14)}$$

Thus the collateral ratio $Collat$ and change of corporate financial environment X not only shift the loan supply curve inward or backward, but also influence r_L^* through the change of the shape of loan supply curve.

Appendix 2: Basic Concept of Switching Regression

Swithching regression model used in this paper is based on Maddala and Nelson (1974). The basic concept of the model is as follows. Now suppose the system consisting of two structural equations as shown below:[46]

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[44] In this case, the second-order condition is $C_{LL} > 0$, which is automatically met from the assumptions about cost function below.

[45] $C_{LL}\left(=\partial^2 C/\partial L^2\right) > 0$ indicates that marginal cost of lending increases with its scale and $C_{LD}\left(=\partial^2 C/\partial L \partial D\right) < 0$ indicates that there exists the economies of scope between lending and the acquisition of deposits. For details, refer to Kasuya (1986) and Yoshioka and Nakajima (1987).

[46] In this section we explain the case where there is no sample separation rule and the full sample is used in both regressions.

$$y^*_{0i} = \beta'_0 x_{0i} + \varepsilon_{0i}, \varepsilon_{0i} \approx N[0, \sigma_0] \quad \text{(A-15)}$$

$$y^*_{1i} = \beta'_1 x_{1i} + \varepsilon_{1i}, \varepsilon_{1i} \approx N[0, \sigma_1] \quad \text{(A-16)}$$

$$Cor[\varepsilon_{oi}, \varepsilon_{1i}] = \rho_{10} \quad \text{(A-17)}$$

where y is a dependent variable, x is an independent variable, β is the coefficient vector, ε are error terms[47] and ρ_{10} is the correlation coefficient, respectively. Here we assume that y is on the short side between equation (A-15) and equation (A-16). This assumption adds the following short-side principle to the system.

$$y_i = min(y^*_{0i}, y^*_{1i}) \quad \text{(A-18)}$$

The estimators $\hat{y}$ are a series of probability weighted average of the value of y^* obtained by equation (A-15) and equation (A-16) respectively. That is, we can obtain $\hat{y}$ in the following manner:

$$\hat{y} = Prob[y = y^*_0]\beta'_1 x_1 + Prob[y = y^*_1]\beta'_0 x_0. \quad \text{(A-19)}$$

Here, $Prob[y = y^*_0]$ is the probability that by the short-side principle y^*_0 is realized as y. It is computed as below.

$$\begin{aligned} Prob[y = y^*_0] &= Prob[\beta'_0 x_0 + \varepsilon_0 < \beta'_1 x_1 + \varepsilon_1] \\ &= Prob[\varepsilon_0 - \varepsilon_1 < \beta'_1 x_1 - \beta'_0 x_0] \end{aligned} \quad \text{(A-20)}$$

Let $\sigma = [\sigma^2_1 + \sigma^2_0 - 2\rho\sigma_1\sigma_0]$, then

$$Prob[y = y^*_0] = \Phi[(\beta'_1 x_1 - \beta'_0 x_0)/\sigma]. \quad \text{(A-21)}$$

As for the estimation procedure, first we estimate the initial values of each parameter using full sample and second, calculate iteratively based on the maximum likelihood method.[48]

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[47] It is assumed that the mean is zero and the variance is constant.
[48] LIMDEP ver.6.0 is used as a software.

Appendix 3: Data Appendix

Details of the data used in this paper are as follows. Each bank data is obtained from *Analysis of Financial Statements of All Banks* (Federation of bankers Association of Japan).

L_{it} : Loans and discounted outstanding at the end of fiscal year on the balance sheet including trust account.

r_{Lit} : Interest on loans and discounted divided by L_{it}.

D_{it} : Deposits outstanding at the end of fiscal year on the balance sheet.

DI_{it} : Diffusion index on business conditions in the area where the head office of bank *i* exists. As for city banks, aggregate (average) data is used.
Source: *Economic Survey of All Enterprises*, Bank of Japan.

$\left(\frac{Int}{Cash}\right)_t$: Interest and discount payable divided by cash flow plus interest and discount payable. Cash flow is defined as current profit plus depreciation.
Source: *Financial Statement of Incorporated Business*, Ministry of Finance.

Bad_{it} :Transfer to reserve for possible loan losses plus written-offs claims on statement of income divided by L_{it}.

$Sinyo_{it}$:The ratio of unsecured loans to L_{it}.

$Fund_{it}$: Funding cost defined as

$$\frac{\left\{\begin{array}{l}\text{Interest on Deposits \&}\\ \text{Debentures (Including}\\ \text{Redemption of discounts}\\ \text{on debentures)}\end{array} + \begin{array}{c}\text{Interest on}\\ \text{Certificates}\\ \text{of Deposit}\end{array} + \begin{array}{c}\text{Interest}\\ \text{on Call}\\ \text{Money}\end{array} + \begin{array}{c}\text{Interest}\\ \text{on Bills}\\ \text{Sold}\end{array} + \begin{array}{c}\text{Interest on}\\ \text{Borrowings}\end{array} + \begin{array}{c}\text{Expenses}\\ \text{(Including}\\ \text{debenture}\\ \text{expenses)}\end{array} + \begin{array}{c}\text{Interest on}\\ \text{Foreign}\\ \text{Exchange}\\ \text{Account}\end{array} + \begin{array}{c}\text{Interest}\\ \text{on Other}\\ \text{Liabilities}\end{array}\right\} \times \frac{365}{\text{Days of Term}}}{\begin{array}{c}\text{Average amount}\\ \text{of Deposits \&}\\ \text{Debentures}\\ \text{Outstanding}\end{array} + \begin{array}{c}\text{Average amount}\\ \text{of Cerificates}\\ \text{of Deposit}\\ \text{Outstanding}\end{array} + \begin{array}{c}\text{Average amount}\\ \text{of Call Money}\\ \text{Outstanding}\end{array} + \begin{array}{c}\text{Average amount}\\ \text{of Bills Sold}\\ \text{Outstanding}\end{array} + \begin{array}{c}\text{Average amount}\\ \text{of Borrowings}\\ \text{Outstaning}\end{array} + \begin{array}{c}\text{Average amount of}\\ \text{Foreign Exchange}\\ \text{Account Outstanding}\end{array} + \begin{array}{c}\text{Average amount}\\ \text{of Other}\\ \text{Liabilities}\end{array}}.$$

$Margin_{it}$: Yield on lending minus funding cost.

TD_i : Dummy variable for city banks(city banks=1, otherwise=0).

CD_i : Dummy variable for regional banks(regional banks=1, otherwise=0).

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