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The Credit Risk of Japanese Banks during the Bubble Period: A Pilot Study of Macro Stress Simulation

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Abstract

This paper estimates the aggregate credit risk inherent in the loan portfolio of Japanese banks during the bubble period. The estimation results suggest that, if a sufficiently prudent (or forecastable from the theoretical relationships observed in the past) scenario could have been projected for the probability of bankruptcy, the concentration of credit and the future fluctuation of collateral prices at the end of fiscal 1989, the magnitude of non-performing loans currently held by Japanese banks could have been predicted. Of course, it is a matter of debate whether or not individual banks could have projected such a scenario at that time. However, there is a close relationship among the three risk factors used in the simulation, namely, (1) concentration of credit in the real estate and related industries, (2) correction of the deviation of land prices from their theoretical values, and (3) deterioration of the credit situation of the real estate and related industries, such that the first risk factor leads to the second risk factor, which in turn results in the third risk factor after a fall in land prices reduces the value of collateral. This suggests the tremendous usefulness of developing and improving a methodology to measure risk from the past relationships. From this standpoint, there is a need to further develop the type of research conducted in the paper, namely, that in which the methodology of risk analysis in the finance literature is combined with the results of macroeconomic research concerning the future anticipated fluctuations of real economic activities.

Key Words: Credit Risk, Extended Value at Risk, Macro Stress Simulation, Asset Price Bubble, Macro Prudential Policy.

JEL Classification Code: G10, G11, G21.

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I. Introduction

Looking at the land price problems in the bubble period from the view point of prudential policy, the question is whether the potential risks of the Japanese economy, such as rapidly rising land prices, concentration of bank loans in the construction and real estate industries, could not have been predicted.

In line with the motivation, this paper tries to quantify the credit risk of Japanese banks and to examine the implications of the estimation results.[1] To be specific, we first define the credit risk of Japanese banks during the bubble period as "the maximum predicted value of the loss caused by the uncertainties of various risk factors that determine the portfolio value." We then apply the framework of measuring micro credit risk quantitatively, that is, an area of active research in financial engineering during the past several years.[2] In other words, our objective is to conduct a stress simulation (a procedure to evaluate beforehand the risk inherent in a portfolio by projecting a sudden change in the market environment) for the bubble period by applying the technique of financial engineering that has seen a considerable development in the 1990s, and thereby to recognize the problem experienced by Japanese financial system as a realization of the aggregate credit risk.

II. Framework for Estimating the Credit Risk

In this section, we will discuss the basic framework of measuring the aggregate credit risk in the banking sector by applying the concept of extended value-at-risk, which was developed by Oda and Muranaga (1997) as a methodology of quantitatively evaluating credit risk of a portfolio.

A. Basic Framework of Estimation

We think of the loan portfolio of city banks, and perform a simulation to see how the fluctuations of the default probability, interest rates and collateral prices might affect the occurrence or non-occurrence of default for a specific time period. In other words, credit risk is defined here as "the maximum predicted value of the loss caused by the uncertainties of various risk factors that determine the value of the assets constituting the portfolio."

In measuring credit risk, the variables that are generally recognized as possible

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[1] In this paper, we will focus on city banks only.

[2] For details, see Oda and Muranaga (1997).

risk factors include: (1) the credit-worthiness of borrowers; (2) the degree of portfolio diversification (or the degree of credit concentration); and (3) how much is covered by collateral (collateral coverage ratio) as well as how much can be recovered (recovery ratio) in case of default. However, because this paper tries to estimate aggregate risks without using micro information (such as the content of loan agreements by individual banks), it first uses one common default probability for each type of industry, as the measure of credit-worthiness of borrowers. We quantify the diversification of the portfolio as a coefficient, by assuming that all portfolios can be thought of as lying on the spectrum from perfect diversification to perfect concentration. Concerning the collateral coverage and recovery ratios, furthermore, we also assume that the portfolio averages are given. Consequently, of the three risk factors, only the credit-worthiness of borrowers (the probability of default by industry type) and the collateral coverage ratio (collateral prices) are assumed to change during the period in which risks are being measured.

B. Modeling the Fluctuation of Risk Factors

As stated above, in measuring the aggregate credit risk, we assume three risk factors: (1) the credit-worthiness of borrowers; (2) the degree of portfolio diversification; and (3) the collateral coverage ratio and the recovery ratio in case of default.

In measuring risk, it is necessary to somehow assume how much the risk factors fluctuate. At financial institutions, the general methodology of measuring market risk is to assume a normal distribution for the fluctuations of risk factors and to assume a confidence interval (for example, 2.33 s at the 99 percent level) based on the historical volatility.[3] In this paper, we assume that for the fluctuation of the credit-worthiness of borrowers, fluctuations are within a certain confidence interval, as in the case of market risk. For the collateral prices, we use a methodology of applying several predetermined scenarios for price fluctuations in measuring the risk.

In what follows, we will explain what assumptions we make for the three risk factors in our estimation of risk.

1. The variable indicating the credit-worthiness of borrowers

Because of wide data coverage, the probabilities of bankruptcy as provided by the Teikoku Data Bank for different industry types or different credit ratings are often used as the measure of the credit-worthiness of borrowers. However, it is pointed out that

[3] For example, such methodologies include the variance-covariance method and the Monte Carlo Simulation method.

the definition of 'bankruptcy' used by the Teikoku Data Bank does not adequately cover the manifestation of credit risk as reflected when the loans extended become non-performing although the borrowers do not run into bankruptcy. As a way to address this problem, some have calculated credit risk by using data on the probability of default, which is obtained by adding the cases of 'financial assistance' to the cases of bankruptcy (See Table 1 for a comparison of the probabilities of bankruptcy and default for different industry types).[4]

Thus, in this paper, we will compare the results obtained from using the more general bankruptcy probabilities as a measure of the credit-worthiness of borrowers with those obtained from using the default probabilities that correspond more broadly to the possibility that the loans become non-performing. We will also compare the results obtained from the measure of risk based on the historical data preceding fiscal 1989 with those obtained from the measure of risk based on the assumption that, in anticipation of the bursting of the bubble, the credit situation of the construction, real estate and finance-related industries would deteriorate (using the actual rates of default for the period 1990-1994).

2. Portfolio diversification

We will compare the measure of risk obtained on the basis of average diversification with the measure of risk obtained on the basis of credit concentration (for example, large-lot loans are extended to a few industries).[5] To be specific, we will calculate the measures of risk when we give a higher coefficient of concentration to the real estate and finance-related industries and when we do not. Here, what we mean by 'a higher coefficient of concentration' corresponds to the situation in which, whereas 10 percent each of total loans is equally extended to 10 borrowers in the average case, more than 90 percent of total loans are extended to three out of the total of 10 borrowers.

3. Future fluctuations of collateral prices

We will use the real estate price index (for the commercial land in the six largest cities)

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[4] See Inoue (1996).

[5] The parameter α is set equal to the average degree of portfolio diversification of Japanese banks, which is based on interviews conducted with financial institutions engaged in quantifying credit risk. To be specific, α is set in such as way as to make the magnitude of dynamic credit risk (the first term of equation (2) below) equal to the magnitude of risk caused by concentration (the second term).

as the variable to capture the fluctuation of collateral prices.[6] We will calculate the credit risk measure for the following two scenarios on the fluctuation of the collateral prices, that is, (1) the collateral price remains at the level in the second half of fiscal 1989 and (2) the deviation between the market price and the theoretical price at the second half of fiscal 1989 is eliminated in five years (see Figure 1).[7]

It should be noted that, the theoretical land price is calculated by taking the present discounted value of future flow of rents, as follows,

$$LP = \frac{R}{i + \rho - \pi}, \qquad (1)$$

where LP, R, i, ρ, and π represent respectively land price, housing and land rent, nominal interest rate, risk premium, expected rate of increase in housing and land rent.

Here, it is assumed that (1) the nominal GDP share of total rental income from office space is constant; (2) the growth rate of nominal income is equal to the sum of the potential economic growth rate and the expected inflation rate (assuming perfect foresight over a one-year horizon); and (3) the risk premium is 2.3 percent (given by the difference between the rate of nominal GDP growth for the period fiscal 1981-fiscal 1989 and the yield spread).

It may be objected that it is inappropriate to criticize in hindsight the failure in predicting a fall in land prices. However, we believe that our scenario of land price fluctuation is sufficiently prudent in the following sense. Although the land prices had never declined in absolute level during the post-war period, the land prices as a share of nominal GDP did fall on some occasions. As shown in Figure 2, the land prices as a share of nominal GDP showed a trend decline from the 1960s to the middle of the 1970s, while there was a moderate upward trend from the middle of the 1970s to the early 1980s. From the middle of the 1980s, the share of land prices as a percent of nominal GDP deviated substantially from that trend. Our scenario simply assumes that the land prices as a share of nominal GDP will return to the previous trend, and not that

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[6] Other collateral assets include stocks and other securities as well as deposits. In our estimation, we will use the real estate price (land price) as the variable to indicate the collateral price.

[7] The period of time required for the price to fall back to the theoretical price is made consistent with the period of time in which risks are estimated (5.2 years), with the annual rate of decline of 12.1 percent. The average actual annual rate of decline from the second half of fiscal 1989 to the second half of fiscal 1994 reached 16.0 percent for the commercial land price index of the six largest cities.

the market participants have a special forecasting ability.

Moreover, by plotting the long-term time-series of land prices and their theoretical prices in Figure 3, we find that there was a noticeable deviation between the two during the second half of the 1980s. Here, it is assumed for the present discounted value land prices that (1) the nominal GDP share of housing and land rental is constant (except that the trend changes in the nominal GDP share of land prices are explicitly considered); (2) the risk premium and the expected rate of inflation are ignored; and (3) the actual and theoretical land prices were equal in the first half of fiscal 1983.

C. Estimating the Credit Risk

In order to quantify credit risk, we use a model that simply calculates the expected fluctuation of the portfolio value (the expected value of the predicted loss) and the maximum predicted loss, which is based on the maximum fluctuation of the portfolio value. Specifically, credit risk is calculated in the following manner,[8]

$$CR(t) = E[CR(t)] + \phi\sqrt{v \cdot EX(t)^2 + \alpha \cdot EX(t)^2 \cdot (1-Q)Q}\,, \tag{2}$$

where CR (t) is credit risk at time t; $E[CR(t)]$ is the expected value of credit risk at time t; ϕ is a coefficient used to set a confidence interval (ϕ = 2.33 in the (trial) estimation); v is the variance of the bankruptcy probability around its expected value; $EX(t)$ is the exposure to credit risk at time t (which reflects the future fluctuation of the collateral price); α is a coefficient indicating the degree of portfolio diversification (α = 0 when the portfolio is perfectly diversified); and Q is the cumulative bankruptcy probability.

On the right hand side of equation (2), the first of the two terms inside the square root notation shows the risk associated with a change in the credit-worthiness of borrowers (dynamic credit risk), while the second term shows the fluctuation in credit risk caused by the insufficiently diversified portfolio (i.e., concentration of credit).

The effect of the fluctuation of the collateral price during the period of estimation can be incorporated by excluding the future collateral price from the amount of exposure to credit risk, which is the basis for calculating the credit risk (a fall in the collateral value leads to an increase in exposure). The period of estimation is set equal to the average remaining term to maturity of the loan portfolio of city banks (5.2 years).

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[8] A characteristic of equation (2) is that different risk items are combined in terms of variances. This follows from the possibility that, if they are combined in terms of standard deviations, the amount of risk can be overestimated. It is more realistic to combine them in terms of variances.

III. Estimation Results and Their Implications

A. Estimation Results

The estimation results are reported in Table 2. In the trial estimation, we test the fluctuation in credit risk by assuming five combinations of fluctuation scenarios for the three risk factors.

Case 1, which makes no special assumption for the fluctuations of risk factors, is the baseline for estimation. In this case, the estimated overall credit risk for city banks as a whole is 2.7 trillion yen (against the total loan outstanding of 132.9 trillion yen). In case 2, we used the probability of default instead of the probability of bankruptcy for the risk factor corresponding to the degree of credit-worthiness, in order to estimate the risk that reflects the possibility of loans becoming non-performing prior to bankruptcy. The estimated credit risk is 5.0 trillion yen, about twice the amount of the credit risk estimated in case 1.

In case 3, we calculated credit risk by assuming that the credit situation of the construction, real estate and finance-related industries would deteriorate. In practice, we used the default probabilities realized with the bursting of the bubble. The estimated credit risk in this case is 14.9 trillion yen, about three times the size of credit risk estimated in case 2. In case 4, we assume that the deviation of real estate prices from their theoretical values (the land price bubble) is corrected during the estimation period (at the assumed annual rate of decline of 12.1 percent), and that the credit situation of the construction, real estate and finance-related industries would deteriorate in the same way as assumed in case 3. The credit risk estimated in the case is 17.5 trillion yen.

Case 5 further assumes, in addition to the bursting of the bubble and the deterioration of the credit situation of the related industries assumed in case 4, that the credit was concentrated in the real estate industry and the non-bank financial sector. The estimated credit risk in this case amounts to 22.8 trillion yen. It is interesting to note that this estimate is roughly equal to the sum (22.5 trillion yen) of the total amount of non-performing assets of 12.4 trillion yen published by the Ministry of Finance for the end of fiscal 1996 and the cumulative amount of disposed loans of 10.1 trillion yen estimated by the Research and Statistics Department of the Bank of Japan. [9]

Figure 4 depicts how the estimated credit risk accumulated over time and the

[9] See Ministry of Finance (1996) and Bank of Japan Research and Statistics Department (1996).

cumulative value of disposed loans. The comparison indicates that, the cumulative value of disposed loans falls far short of the cumulative credit risk.

B. Implications of the Estimation Results

The estimation results suggest that, if a sufficiently prudent (or sufficiently forecastable from the theoretical relationships observed in the past) scenario could have been projected for the probability of bankruptcy, the concentration of credit and the future fluctuation of collateral prices at the end of fiscal 1989, the magnitude of non-performing loans currently held by Japanese banks could have been predicted.

Of course, it is a matter of debate whether or not individual banks could have projected such a scenario at that time. However, the fluctuation scenarios for the three risk factors assumed in case 5 (i.e., concentration of credit in the real estate-related industries, correction of the deviation between the land price and its theoretical value, and the deterioration of the credit condition of the real estate-related industries) are closely related to each other, such that the first risk factor brings about the second risk factor that results in a manifestation of credit risk in the form of the third risk factor, when the fall in land prices leads to a fall in collateral prices. Such a scenario can be sufficiently predicted. Thus, if the correction of the deviation between the land price and its theoretical value could have been predicted under the condition of credit concentration in the real estate-related industries, the scenario that the credit condition of such industries would deteriorate could have been sufficiently predicted.

Particularly, Figure 3 shows that the relationship between the actual land price and its theoretical value deviated substantially from the past relationship. Thus, it was possible to recognize the risk inherent in the macroeconomic environment in the early 1990. Because the Bank of Japan was in a position to recognize at an early stage the concentration of credit in the real estate industry and the non-bank financial sector within the loan portfolio of Japanese banks. It is a serious matter that, despite that vantage point, the Bank of Japan failed to recognize the possibility that the credit risk would become manifest in the form of non-performing loans in excess of 20 trillion yen if that scenario were to realize.

From the viewpoint of micro levels (i.e., from the point of view of management of individual banks), these results point to several issues that should be kept in mind in the future management of credit risk. The bankruptcy probability, which is generally used to estimate risk, is not an adequate explanatory variable of the possibility that assets may become non-performing. The historical volatility for the past one year or so, which is generally used in estimating value at risk, is also inadequate from the standpoint of preparation for a future crisis. Concerning this point, it is the idea of ‘stress simulation’ that is becoming established in the management of market risk. In the future, a similar response must be made in relation to the management of credit risk, which is more underdeveloped relative to the management of market risk. Furthermore, in quantifying risk, it will be necessary to incorporate explicitly the effects of credit concentration and fluctuations of collateral prices, which have not been sufficiently recognized in the estimation of credit risk.

However, in order to apply the information obtained from bank examinations to the framework of stress simulation on the aggregate credit risk in the future, it will be necessary to make improvements in the following areas.

(1) A more precise methodology should be developed in the future to quantify the degree of portfolio diversification. An example might be to quantify portfolio diversification by determining patterns of distribution for individual loan exposure in the portfolio.

(2) In this estimation, we have applied the uniform bankruptcy probability for each industry type when checking for the fluctuations in the bankruptcy probability. It will be necessary to examine whether or not the currently available breakdown of industries is adequate, or whether or not it will be possible to obtain more precise results by creating a further breakdown of firms within each industry according to credit rating.

(3) In the estimation, we have used the average collateral ratio of city bank loans and assumed that there is only one type of collateral (real estate) in incorporating the collateral prices. Ideally, it is necessary to consider the possibility that the exposure may change according to the type of collateral and the actual collateral ratio.

(4) We must examine the appropriateness of the scenario assumed in the paper for the correlation between the industry-wise bankruptcy probabilities and the correlation between the fluctuation in the collateral price and the bankruptcy probability, by calculating the correlation coefficients based on historical data.

(5) It should be noted that data on a widely defined probability on default such as those used in the paper are not publicly available at this moment.

IV. Conclusion

This paper estimated the aggregate credit risk inherent in the loan portfolio of Japanese city banks during the bubble period. The estimation results provide to some extent an explanation of the magnitude of non-performing loans faced by Japanese financial system in the aftermath of bursting the stock price bubble. They suggest that, if a sufficiently prudent (or sufficiently forecastable from the theoretical relationships observed in the past) scenario could have been projected for the probability of bankruptcy, the concentration of credit and the future fluctuation of collateral prices at the end of fiscal 1989, the magnitude of non-performing loans currently held by Japanese banks could have been predicted.

Of course, the question is whether individual banks could have projected such a scenario at that time. However, there is a close relationship among the three risk factors used in the estimation, that is, (1) concentration of credit in the real estate and related industries, (2) correction of the deviation of land prices from their theoretical values, and (3) deterioration of the credit situation of the real estate and related industries, such that the first risk factor leads to the second risk factor, which in turn results in the third risk factor after a fall in land prices reduces the value of collateral.

Keep these conclusions in mind, we are convinced that the researches linking financial engineering with economics is an important research area awaiting development. This paper is a starting point for these researches in the sense that combines the methodology of risk analysis in the financial engineering with the forecast of fluctuations of real economic activities applying the basic macroeconomic theory.

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Table 1. The Bankruptcy and Default Probabilities of Japanese Listed Companies (in percent; average for fiscal 1980-1994)

unit: %

	bankruptcy probability	default probability
All industries	0.08	0.24
Manufacturing	0.08	0.19
Non-manufacturing	0.07	0.31
of which, construction and real estate	0.00	0.20
other financial institutions	0.00	2.50

Source: Inoue (1996).

Note: The bankruptcy probability was zero for the construction and real estate companies and other financial institutions, because there was no bankruptcy involving listed companies in these industry categories during fiscal 1980-1994.

Table 2. The Credit Risk of the Loan Portfolio of City Banks (end of March 1990)

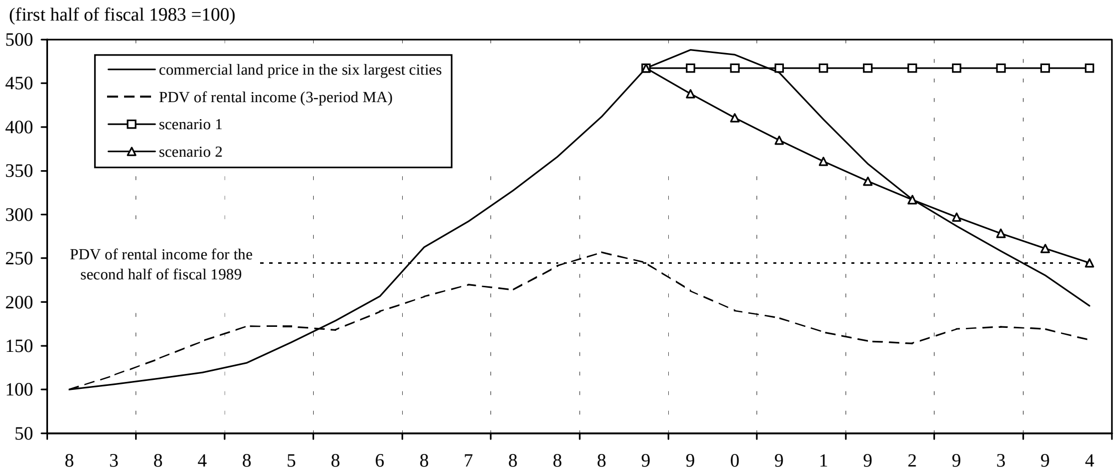
Unit: in trillions of yen

	Bankruptcy probability (observation period)	Assumption about portfolio diversification	Scenario for the future fluctuation of collateral prices	Amount of credit risk	
					of which, concentration risk
1	Bankruptcy probability ('85-89)	Average diversification	Constant	2.7	1.6
2	Default probability ('85-89)	Average diversification	Constant	5.0	2.7
3	Default probability ('90-94) with assuming deterioration of the credit situation of the construction, real estate and finance-related industries	Average diversification	Constant	14.9	6.0
4	The same as above	Average diversification	the deviation from the theoretical value is eliminated in 5 years	17.5	6.9
5	The same as above	Credit concentration in the real estate and finance-related industries is assumed (α: 0.1 → 0.3)	The same as above	22.8	10.5

Note: 1. "Concentration risk" refers to the amount of risk when dynamic risk is assumed to be zero.

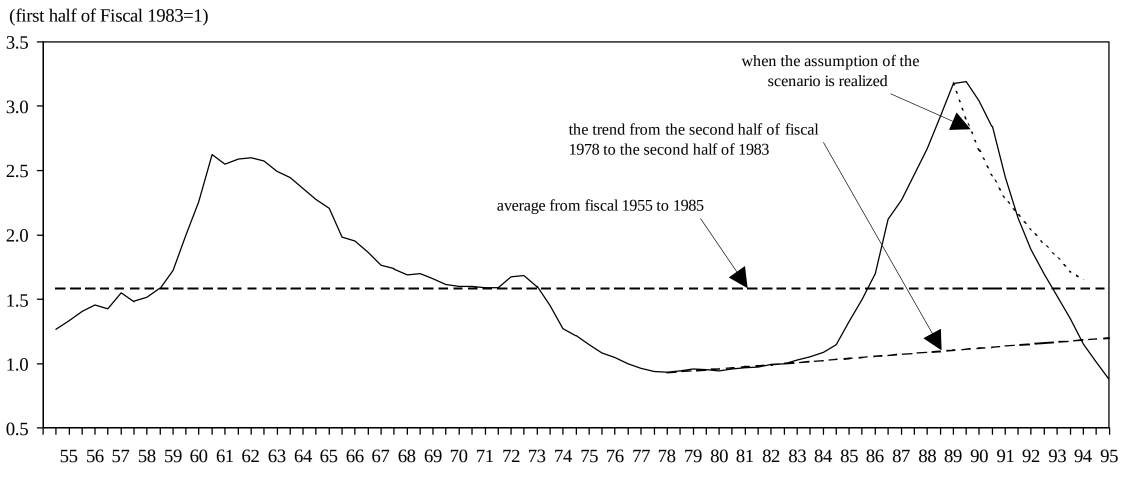
2. In Case 3, the following increases for the default probability is assumed: for the construction industry, from 0.0 percent to 0.40 percent; for the real estate industry, from 0.0 percent to 0.59 percent; and for the finance-related industry, from 0.0 percent to 7.49 percent.

Figure 1. Scenarios for Land Price Fluctuation



Notes: 1. It is assumed for the price fluctuation after the second half of fiscal 1989 that the price will fall at a constant rate so as to eliminate the deviation from the present discounted value in 5 years.
2. The present discounted value land price is calculated by assuming that (1) total rental from office space remains constant as a percent of GDP, (2) the rate of growth of rental income is equal to the rate of potential economic growth and the expected rate of inflation (with perfect foresight over a one-year horizon), and (3) the risk premium is 2.3 percent (given by the difference between the rate of nominal GDP growth for fiscal 1981-1989 and the yield spread).

Figure 2. Land Prices as A Ratio to Nominal GDP



Note: "When the assumption of the scenario is realized" shows the ratio of the level of land prices assumed in the scenario to the realized nominal GDP.

Figure 3. Land Prices

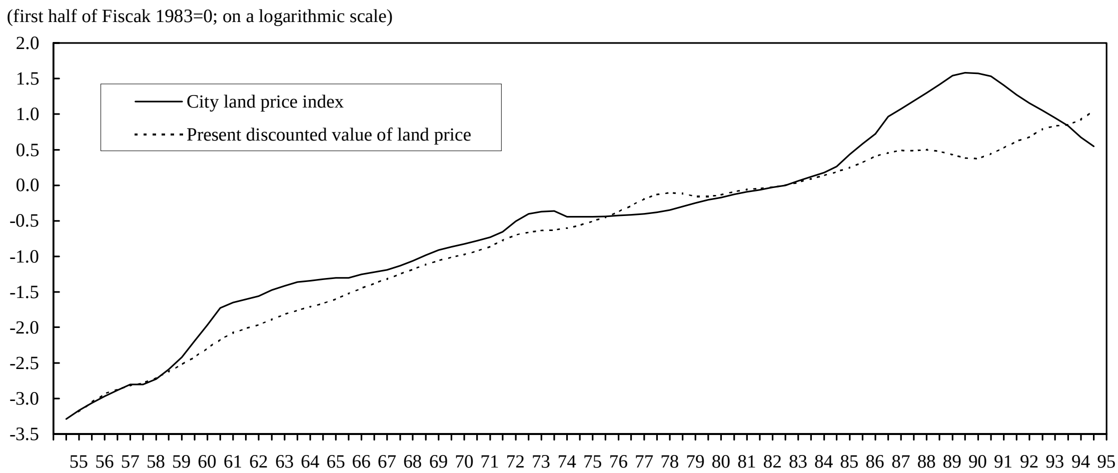


Figure 4. The Amount of Credit Risk and the Actual Amount of Redemption