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Do Banks Reduce Lending Preemptively in Response to Capital Losses? Evidence from Japan*

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Abstract

We empirically examined whether declining bank loans in Japan in the late 1990s are the result of banks' downward adjustments of lending supply (a "credit crunch") in response to capital losses (a "capital crunch"). Estimating the new lending supply function as a non-linear function of the capital to asset ratio, we found that the (new lending supply) function is not only increasing in bank capital but also concave in bank capital, which supports the view that a "credit crunch" occurs since forward-looking banks have an incentive to avoid failing to meet regulatory requirements in the future.

Keywords:
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1. Introduction

The goal of our study is to empirically examine whether declining bank loans in Japan amid the prolonged economic slump in the late 1990s are the result of the banks' downward adjustments of lending supply (a "credit crunch") in response to losses of capital (a "capital crunch"). In doing so, we estimate a bank's new lending supply as a function of the bank's capital to asset ratio.

Under the current internationally harmonized regulatory framework based on the Basel Accord, a bank has an incentive to reduce the supply of loans in the wake of loss of its own capital. The framework requires that the ratio of capital to risk weighted assets of a bank known as the RBC (risk based capital) ratio not be below the minimum standard specified by the domestic regulator. Since lending has been assigned the highest 100 percent risk weight irrespective of the credit risks of each contract, reducing the supply of loans would allow the bank to restore the RBC ratio without raising equity capital.

Declining bank loans and large losses of bank capital during a severe economic downturn have been widely observed. The Japan's experience in the late 1990s was shared by the US and Europe, particularly the Scandinavian countries, in the early 1990s, and East Asian countries in the late 1990s.[1]

From a theoretical standpoint, the fact that the relationship between bank capital and bank loans emerges in the periods of large capital losses and is negligible at other times suggests that banks insure against unanticipated adverse capital shocks by aggressively adjusting supply of loans when their capital positions come close to the regulatory minimum. Banks do not engage in such preemptive actions when they are well

[1] For the US evidence using micro data on banks, see Bernanke and Lown (1991), Berger and Udell (1994) and Peek and Rosengren (1995 a, b, c). For the Japanese evidence, see Woo (2003) and Watanabe (2005).

capitalized since capital losses large enough to threaten failing to meet the regulatory requirement are unlikely. As Van den Heuvel (2002) demonstrates in his simulation study, the forward-looking bank's reaction to capital loss is characterized by a (new) lending supply function that is increasing and concave in bank capital. In running regressions, various non-linear functional forms are examined to capture the concavity of the (new) lending supply function.

It is important to know whether declining bank loans are the banks' downward adjustments of lending supply in response to losses of capital or simply reflect the declining borrowing demand due to lack of profitable investment opportunities during the economic slump. Therefore, it is only when banks are unwilling to lend due to their concerns about capital requirements that public recapitalization of banks is effective in restoring supply of bank credits to the real sector.

Following Watanabe (2005), as an attempt to identify lending supply with borrowing demand, we use the real estate lending share within the bank's lending portfolio in the late 1980s as an instrumental variable for bank capital in the 1990s. Since the heavier the bank's involvement in the real estate lending in the 1980s was, the heavier the burden of non-performing loans in the 1990s was and the lower bank capital was, the employed instrument effectively picks up an exogenous shock to bank capital unaffected by the current economic conditions.

Our finding that the estimated (new) bank lending supply function is not only increasing in bank capital but also shows the strong concavity in bank capital very much like the one the simulation of Van den Heuvel (2002) shows, supports the view just mentioned above that a "credit crunch" occurs when forward-looking banks have an

incentive to avoid failing to meet the regulatory requirement in the future.

The remainder of the paper is arranged as follows. In Section 2, we discuss the relevant background and the theoretical motivation. In Section 3, data and econometric issues are set out. In Section 4, results are reported and some policy implications are drawn. Section 5 concludes the paper.

2. The Relevant Background and the Theoretical Motivation

2.1. The Basel Capital Accord and its Domestication

The ongoing Japanese regulation framework based on the Basel Accord (hereafter, the domestic regulation framework based on the Basel Accord is referred to as "the Basel (regulation) framework" to distinguish from the original Accord), which was agreed in 1988 and has been effective since FY 1992 in Japan, requires that the ratio of capital to risk weighted assets (riskier assets are assigned a higher weight and vice versa) not be below the specified minimum standard. Loans are assigned a 100 percent risk weight, irrespective of the credit risks of each contract (credit worthiness of each borrower).

The Basel Accord was originally motivated to harmonize domestic banking regulations, which varied from one country to another, so that banks operating in multiple countries are subject to the internationally unified regulatory standards. Taking advantage of the original spirit of the Accord, the Japanese regulator opted to set double standards for internationally operating banks (hereafter referred to as "international banks") and for banks allowed to operate only domestically (hereafter referred to as "domestic banks"). The minimum standard for "domestic banks" is relaxed the minimum standard to the half (4

percent) of that for “international banks” (8 percent).

The Basel framework allows banks to supplement core capital called Tier 1 by quasi capital instruments called Tier 2. Tier 1 includes equity capital and published reserves from post-tax retained earnings and matches approximately “equity capital” in a bank balance sheet. Elements that can be included in Tier 2 are undisclosed reserves, (asset) revaluation reserves, general provisions/general loan-loss reserves, hybrid debt capital instruments, and subordinated term debts. The framework mandates banks to satisfy half of the minimum standard (4 percent for “international banks” and 2 percent for “domestic banks” under the current Japanese regime) by Tier 1 elements.

Indeed as Ito and Sasaki (2002) evidence, Japanese banks have effectively avoided a shortfall of the RBC ratio relative to the regulatory minimum by issuing quasi capital instruments such as subordinated debts when core capital is lost. Another evidence on the banks’ control of the RBC ratio is that none of banks failed to meet the regulatory minimum even during the period of the severest “capital crunch” in FY 1997 when the regulator requested banks the rigorous self assessment of their assets, which lead to realizations of huge amount of non-performing loans on their financial statements that had been previously left unrecognized.

2.2. Why Does a “Capital Crunch” Cause a “Credit Crunch”?

So far as an international (a domestic) bank does not violate the Tier 1 requirement of 4 percent (2 percent), it manages to make up for a loss of core capital by issuing Tier 2 supplemental instruments. It is when a large loss of capital threatens the bank a shortfall of the ratio of core capital to the risk adjusted assets (the Tier 1 ratio) relative to the Tier 1

requirement that the bank's incentive to raise the Tier 1 ratio arises.

When a bank needs to raise the Tier 1 ratio, technically speaking, there are two available ways, either drumming up the numerator of the Tier 1 ratio by issuing new equity or reducing denominator of the ratio by reducing assets with higher risk weights such as loans. Issuing new equity is difficult due to the adverse selection problem described by Stein (1998). If a bank issued new equity to make up for capital it lost for investing unwisely into too risky assets (loans), who on earth would take up such equity? Indeed, none of large banks that went through the severest "capital crunches" among Japanese banks issued new equity in the markets during the aftermath of large write offs of non-performing loans in FY 1997.

So, in practice, reducing assets with higher risk weights is the only way available to a bank in order to achieve the restoration of the Tier 1 ratio when a large amount of bank capital is lost. Since loans are the dominant bank assets with higher risk weights, the bank has a strong incentive to stop rolling over loans when their maturity arrives.[2] This is why a "capital crunch" leads to reduced supply of bank loans, or, so called a "credit crunch".

2.3. A "Credit Crunch" as an Insurance against Unanticipated Adverse Capital Shocks

Suppose a bank is forward-looking and is uncertain of capital losses in the future. Then the bank has a strong motive to reduce supply of loans when its capital adequacy is sufficiently close to the regulatory requirement. The well capitalized bank is less motivated to reduce supply of loans since a future capital loss large enough to threaten the

[2] Japanese banks are allowed to hold stocks and the presence of stocks in the banks' assets is not negligible, selling them would realize capital losses in the depressing stock markets after the burst of the bubble, which would lead to further capital losses.

bank a failure to meet the regulatory requirement are unlikely to occur.

Van den Heuvel (2002) is the first attempt to formalize the abovementioned forward-looking behavior of a bank under the RBC requirement. He models the bank, which maximizes a sum of discounted dividend payouts to its shareholders, when the capital to loan ratio (the RBC ratio) is bounded below by the regulatory minimum standard and finds that at the optimum the new lending is an increasing and concave function of the "excess" capital, which is defined as actual capital less the minimum required capital, by a numerical simulation.[3]

Figure 1 is the simulation results presented on Figure 4 of Van den Heuvel (2002). The minimum required capital is 8 percent of outstanding loans carried over from the previous period, which is unaffected by new supply of loans made in this period.[4] Thus, the characteristics that an optimal policy function for new lending is increasing and concave would be preserved when the ratio of capital to risk unadjusted assets replaces the "excess" capital unless bank's capitalization far exceeds the minimum requirement.

If a bank were able to foresee the future perfectly, and as a result, there were no unanticipated downward shocks to capital, it would have no motivation to hold the "excess" capital. Since loans are the dominant assets with positive risk weights, and weights for most loans are fixed at 100 percent under the current Basel framework, the bank would hold the amount of capital roughly proportional to its outstanding loans at an optimum. Thus, the size of outstanding loans would shrink (rises) by the amount roughly proportional

[3] Kato and Nishiyama (2004) simulates the central bank's adjustment of the short rate when the short rate is bound below at zero and find that the short rate is an increasing and concave function of the expected rate of inflation.

[4] 8 percent is the globally accepted minimum standard for the RBC ratio. Keep in mind that the 4 percent minimum requirement for "domestic banks" in Japan is an exception to the standard Basel guideline.

to the amount of lost capital (rise in capital) each period. In this case, the "optimal" policy function for new lending supply would be a linear function of bank capital.

3. Data and Econometrics

3.1. Data

The main data source of bank level data is the Nikkei NEEDS bank financials data bank. It has become fairly standard for the analysis of Japanese banks recently (Ogawa and Kitasaka [2000], Hoshi and Kashyap [2000], Ueda [2000], and Hoshi [2001]). The data represents a 27 year-long period from FY 1974 to FY 2000. It contains not only balance sheets and income statements of all domestically licensed banks, but also details of lending classified by industry, by types of collateral, by use (equipment funds/working capital), as well as the amount of lending to small and medium sized firms. The Basel RBC ratios and unrealized gains on assets are taken from the Japanese Bankers Association's Analysis of Financial Statements of All Banks.[5]

3.2. Sample Selection

We drop banks affected by bank failures, failed (liquidated or nationalized) banks, as well as banks having experienced rescue mergers or acquisitions of financially distressed banks. A failed bank is by definition insolvent and has tended to be undercapitalized until its exit.[6] A bank's assets (loans) are usually substantially downsized when it is liquidated

[5] Missing items on recent balance sheets of a few banks are supplemented by their annual reports.
[6] It is commonly observed that banks that looked financially viable due to a creating accounting policy to cover up non-performing loans suddenly fail when non-performing loans are finally recognized and reflected on their financial statements.

or a new management takes it over from an old management. Thus, there is, almost by definition of a bank failure, a strong positive relationship between the failed bank's new lending and its capital adequacy. Therefore, including banks affected bank failures would overestimate a "credit crunch" due to a "capital crunch". Referring to a "credit crunch", we mean that financially solvent banks become unwilling to lend out due to their concerns about their regulatory minimum standards for the RBC ratio. A total of 125 banks remain in the sample. [7]

3.3. The Empirical Model

Consider the following equation.

$$\frac{NL_{it}}{L_{it-1}} = \alpha_0 + \alpha_1 \frac{NL_{it-1}}{L_{it-2}} + \beta f\left(\frac{K_{it}}{A_{it}}\right) + \gamma X_i + \eta_i + \varepsilon_{it} \qquad (1)$$

The dependent variable NL_{it}/ L_{it-1} is the bank *i*'s new lending normalized by outstanding loans at year *t*. The new lending NL_{it} is calculated as a sum of a net increase in outstanding loans and disposal of non-performing loans (loan write-offs). K_{it}/ A_{it} is the present book based capital to asset ratio. f is a (non-linear) function. Other independent variables are the lagged dependent variable and X_i, a set of dummy variables (CITY, TRUST, and REGIONAL) that control for the bank's institutional characteristics and indicate a city bank, a trust bank, and a regional bank, respectively. Since each group of banks has a distinctive customer base, X_i is meant to control for lending demand.[8] η_i is a

[7] Banks having experienced non-rescue mergers are treated as single banks in pre-merger dates by adding values of variables for banks involved in the deals. Industrial Bank of Japan was dropped since detailed lending data for the 1980s are missing. Yachiyo Bank that was founded in the 1990s is also dropped.

[8] Dummy variables are based on the conventional classification of Japanese banks. Regional 2 banks are used as a base group. Long-term credit banks do not survive in the construction of the analyzed sample.

bank specific fixed effect and ε_{it} is the error term.

3.4. The Measure for the Capital to Asset Ratio

The ratio of book capital to total assets (book-based ratio) is used as the capital measure when estimating equation (1). There are two other possible candidates-- the BIS risk based capital asset ratio and the market-based capital asset ratio that includes unrealized gains (or losses) on bank assets as capital. The book-based ratio is superior for two main reasons.

First, the Basel regulatory framework requires that at least 50 percent of capital required to meet the minimum capital requirement be core (Tier 1) capital, which roughly corresponds to book capital. Second, by normalizing capital by risk-"unadjusted" assets, we are able to isolate shocks to capital. Normalizing instead by risk-"adjusted" capital would result in a feedback effect from the growth of the supply of loans (the dependent variable) to the capital asset ratio through the denominator (of an independent variable).[9] Besides, banks can control the level of BIS capital by issuing supplemental *quasi-capital* instruments such as subordinate debts in the wake of the loss of core capital. The Basel regulatory framework does not impose a minimum requirement for the market-based ratio.

3.5. Testing on the Concavity of the New Lending Supply Function

We use various specifications that are meant to capture the possible concavity of the increasing new lending supply function.

As a starting point, we use the quadratic function. The quadratic function is the most

[9] The larger the outstanding loans are, the larger the risk adjusted asset is, and the smaller the risk-adjusted capital asset ratio is since loans are assigned the highest risk factor of 100 percent.

general functional form since it can be interpreted as a second-order Taylor expansion of the (concave) optimal new lending function. The quadratic function is increasing and concave for the range of reasonable (not too large) values for the argument (the capital to asset ratio), when the coefficient of the first order term is positive and the coefficient of the second order term is negative.

Next, we use a logistic function that has the following three characteristics of the simulated optimal new lending function: 1. increasing, 2. concave, and 3. the slope is asymptotically zero as the argument gets large. A general form for a logistic function is given by the following expression.

$$f\left(\frac{K_{it}}{A_{it}}\right) = \frac{\exp\varphi\left(\mu - \frac{K_{it}}{A_{it}}\right)}{1 + \exp\varphi\left(\mu - \frac{K_{it}}{A_{it}}\right)} \qquad (2)$$

φ and μ are parameters to be estimated. Hubbard, Kuttner and Palia (2002) use a logistic function to capture a possibly non-linear relationship between bank capital and the contractual lending rate but finds no evidence of non-linearity.

3.6. Correcting Endogeneity Biases

Removing fixed effects

The bank specific fixed effect η_i may be correlated with both the capital to asset ratio and the new lending, thereby violating the regularity conditions that the OLS estimator is unbiased. The fixed effect may for instance capture the bank's risk averseness (corporate culture). Banks with a tradition of aggressive management that employs the aggressive sales policy likely end up with more non-performing loans by excessive risk taking.

Banks with a tradition of conservative management, on the other hand, likely incur more NPls. We first difference both sides of equation (1) to remove the fixed effect η_i. First differencing results in bank specific bank type dummies, X_i.

Use of instrumental variables

The capital – lending relationship can arise through business cycle fluctuations. If economic conditions worsen, firms adjust their investments downward, which in turn results in declining borrowing demand. On the other hand, firms' sluggish sales performance may prevent them from earning enough revenues to service their debts on time. Thus, their existing loans become non-performing, which reduces lender banks' capital. Similarly, in an economic upturn, borrowing demand soars, and the higher profits of banks are added to their equity capital.

Following Watanabe (2005), we use the share of real estate lending in the bank's lending portfolio in FY 1989, REAL89, as an instrumental variable for bank capital in order to identify the banks' lending supply function with the business cycle driven capital – lending relationship just described. The construction of REAL89 is based on empirical findings by Ueda (2000) and Hoshi (2001) that the tilt in the bank's portfolio toward the real estate industry in the 1980s after losing large *keiretsu* borrowers after the financial deregulation best accounts for the size of NPLs of that bank in the late 1990s.[10]

We also add the 10-year growth of each bank's lending share to the real estate industry since FY 1980 to REAL89 as another instrument.[11]

[10] For the extensive discussion on the validity of REAL 89, see Watanabe (2005).

[11] In addition, constant, predetermined variables including twice and three times lagged loan growths, three times, four times, and five times lagged deposit growth rates, and twice and three times lagged growths of the land price of the prefecture in which headquarters of the bank is located, are included as a

4. Results

4.1. Stylized facts

We first show the macro and micro facts on bank capital and bank loans in the 1990s and see whether there is any indication of the conjectured positive and concave relationship between bank capital and bank loans.

As Figure 2 demonstrates, a sharp fall in the book based capital to asset ratio of domestically licensed banks in March 1998 (at the fiscal year end of 1997) was followed by a long lasting fall in the domestic lending growth. Domestic loans fell by 20 trillion yen, or about 4 percent during the three year period from April 1997 to March 2000. The aggregate evidence is indicative of a "credit crunch" since FY 1998 caused by a "capital crunch" in FY 1997.

Each figure on Figure 3 plots the book based capital to asset ratio and the new lending rate for an individual major bank during the post Basel era (FY 1992 – FY 2000).[12] To our dismay, the capital to asset ratio and the new lending seems to be negatively related for all the major banks. Figure 4 plots the book based capital to asset ratios and the new lending rates for smaller regional and regional 2 banks. Bank-year observations for 111 selected regional and regional 2 banks during the post Basel era are represented. We do not detect any recognizable relationship between the capital to asset ratio and the new lending rate. Observations are heavily clustered. Micro facts seem to be unfavorable to a "capital crunch" driven "capital crunch".

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set of instrumental variables.

[12] Banks included in Figure 1 are so called "major" city banks: Bank of Tokyo Mitsubishi, Sumitomo, Sanwa, Fuji, Sakura and Daiichi Kangyo Banks.

4.2. Preliminary Linear Regression Results

Table 1 shows the results of the OLS and the 2SLS (instrumental variable) regressions when the relationship between the capital to asset ratio and the new lending rate is restricted to be linear. Neither the OLS regression nor the 2SLS regression results in statistically significant relationship between the capital to asset ratio and the new lending rate, supporting our conjecture that the relationship is non-linear.

4.3. Non-linear Regression Results

Table 2 presents our main results from regression equations with a non-linear function of the book to capital asset ratio as one of terms in the right hand side. The regression equations are estimated for a panel of banks for a five year period since FY 1995 through FY 2000 using the 2SLS.[13]

The quadratic specification

The estimated coefficient of the capital to asset ratio is positive and statistically significant at the one percent significance level, whereas that of the square of the capital to asset ratio is negative and significant at the five percent significance level. These estimates are consistent with the concavity of the bank lending supply function.

Figure 5 plots a predicted new lending rate for each bank-year observation based on the estimated quadratic lending supply function. In predicting the (current) new lending rate, the lagged new lending rate is held constant at the sample average of the entire

[13] The sample period ends in FY 2000, since consolidation of large banks starts in FY 2001 and the sample size declines substantially if later dates are included.

bank-year observations.

The quadratic lending supply function captures the concavity of the new lending supply function surprisingly well. It is increasing in the capital to asset ratio when the ratio is less than about 0.035, and reaches around zero and flattens out when the ratio is above about 0.035. The predicted new lending rate is negative when the new lending supply function is increasing. The shape of the estimated quadratic new lending supply function implies that banks are triggered to cut bank on their lending supply if the capital to asset ratio falls short of the threshold level at about 0.035.

The logistic specification

In the logistic function for the book based capital to asset ratio expressed in equation (2), to make econometrics tractable, we set parameters, φ and μ, to be set at -100 and 0, respectively.[14] The coefficient of the logistic term β is estimated to be positive and statistically significant at the one percent significance level, which suggests the strong concavity of the increasing new lending rate function.

Figure 6 plots a predicted new lending rate for each bank-year observation based on the estimated lending supply function with a logistic term for the capital to asset ratio. In predicting the (current) new lending rate, the lagged new lending rate is held constant at the sample average as is done with the quadratic new lending supply function.

The estimated new lending function is increasing when the capital to asset ratio is less than about 0.04. The estimated function is flat when the capital to asset ratio is above 0.04.

[14] The choice of parameter values may be subject to a criticism for being ad-hoc. For the sake of drawing prudential policy implications, however, capturing non-linearity of the lending supply function is sufficient. The GMM estimation of parameters that enter non-linearly in the lending supply function is an interesting research direction from the econometric standpoint.

The shape of the estimated new lending supply function with a logistic term is consistent with that of the estimated quadratic new lending supply function. Banks start to react in response to undercapitalization by reducing lending when the capital to asset ratio falls short of the trigger point at around 0.035.

The estimated new lending supply function with a logistic term and the Van den Heuvel's simulation based new lending supply function presented in Figure 1 are surprisingly similarly shaped. Our empirical finding strongly supports the theory that a forward looking bank makes a non-linear adjustment of the new lending supply in response to a capital loss when the risk adjusted capital to asset ratio is bounded below at the regulatory minimum.

How can the estimated trigger point be compared to the simulated trigger point?

How can the estimated trigger point with respect to the book-based ratio at 3.5 percent be comparable to the simulated trigger point with respect to the Basel risk adjusted capital to asset ratio at around 15 percent simulated by Van den Heuvel (2002)? The simulated 15 percent is based on the 8 percent minimum standard for entire regulatory capital including supplemental Tier 2 elements. The trigger point with respect to core capital based on the 4 percent minimum standard should be roughly half at 7.5 percent. During the sample period, the share of loans in the Japanese banks' total asset ranges from 58 percent to 65 percent. Assuming that the banks' portfolio consists of loans and assets with a zero risk weight such as deposits at the Bank of Japan and the Japanese government bonds, the trigger point with respect to the risk-unadjusted book-based capital to asset ratio at 3.5 percent can be translated into the trigger point with respect to the risk-adjusted core capital

to asset ratio at 5.4 to 6.0 percent, which is comparable to the trigger point based on the simulation at 7.5 percent.

4.4. Robustness Checks

FY 1997 is the turning point of the prudential regulation in Japan. It is at the end of FY 1997 that the regulator (Ministry of Finance) requested banks to assess their assets according to the stringent standard for performance of outstanding loans for the first time and as a consequence that banks had to write off enormous amount of non-performing loans. It is also at the beginning of FY 1998 that larger banks are subject to the regulatory intervention based on their BIS risk adjusted capital to asset ratio.

As robustness checks, we repeat non-linear regressions for the sample period from FY 1997 to FY 2000. The results are reported on Table 3. Signs are consistent with the results for the longer panel from FY 1995, though the estimated coefficients of non-linear terms are smaller than the ones for the longer panel and they are not statistically significant at the 10 percent significance level. Weak results for the shorter panel from FY 1997 may have to do with the fact that the data lack the period during which banks are well capitalized (until FY 1996).[15]

4.5. Policy Implications

[15] One caveat is that not only was FY 1997 the exceptional year when banks experienced serious capital crunches but also the overall sample period (FY 1995 - 2000) could be the exceptional period when banks were less profitable and were more aware of (their capital positions were closer to) the regulatory minimum than they would be in normal times. Our estimate that even adequately capitalized banks barely increase lending may be attributable to such a concern. At the time of writing (March 2006), it is said that banks have finally contained the non-performing loans problem under the favorable economic environment. It is, however, hard to empirically examine the banks' lending behavior under the Basel 1 in "normal" times since the period under the current Basel 1 almost coincides the period of a poor banking sector and the new Basel 2 regulatory framework will start in FY 2007.

Our finding suggest that public recapitalization of FY 1998 did have a favorable effect of containing the credit crunch in FY 1997. Fourteen mostly large banks received public capital at the fiscal year end of 1998 (March 1999).[16] These banks' capital positions were seriously inadequate one year earlier. At the fiscal year end of 1997 (March 1998), the book based capital to asset ratio was *below* 0.03 for eleven of fourteen such banks, suggesting that many such banks had to cut back on their lending supply during FY 1997. After public capital was infused, the book based capital to asset ratio was *above* 0.04 for eleven of fourteen banks, suggesting that many publicly recapitalized banks stopped reducing lending. Table 7 indicates thirteen banks in our sample that received public capital at the end of FY 1998.[17] If the lagged lending growth were the sample average, all such banks would have reduced lending (negative lending) before receiving public capital (FY 1997), and all such banks would have increased lending (positive new lending) after receiving it (FY 1998). Fourteen banks that received public capital at the end of FY 1998 constituted 61 percent of the domestic loans outstanding of domestically licensed banks as of March 1999, which implies that public recapitalization ended the negative macroeconomic impact of the credit crunch due to inadequate bank capital.

Our findings further suggest that the impact of public capital on supply of loans differs across banks with varying extent of capital adequacy. A well capitalized bank, which is not constrained to capital, would not increase supply of loans when they are publicly recapitalized. On the other hand, public recapitalization of a poorly capitalized bank would effectively restore its supply of loans.

[16] Yokohama Bank is an only regional bank that received public capital at the fiscal year end of 1998. Twelve of thirteen major (large) banks in our sample received public capital. The only exception among them is Bank of Tokyo Mitsubishi. For further reference on public recapitalization in F 1998, see Nakaso (1999).

[17] Industrial Bank of Japan is a single publicly recapitalized bank that leaves our sample.

5. Conclusion

We empirically examined whether declining bank loans in Japan amid the prolonged economic slump in the late 1990s are the result of the banks' downward adjustments of lending supply (a "credit crunch") in response to losses of capital (a "capital crunch") by estimating a bank's new lending supply as a (non-linear) function of the bank's capital to asset ratio.

Using non-linear specifications for the term with respect to the capital to asset ratio in the new lending supply function such as a quadratic function and a logistic function, we found that the estimated (new lending supply) function is not only increasing in bank capital but also concave in bank capital, which supports the view that a "credit crunch" occurs when forward-looking banks have an incentive to avoid failing to meet the regulatory requirement in the future.

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Table 1. Linear Regression Results

	OLS	2SLS
Lagged dependent variable	-0.375***	0.476***
	(-9.663)	(4.821)
Book based capital to asset ratio	-0.162	1.192
	(-0.721)	(1.357)
Observations	750	750

Note
1. The dependent variable is the new lending rate.
2. *, ** and *** show that a coefficient is statistically significant at 10 %, 5% and 1% respectively.
3. t statistics are in parentheses

Table 2. Non-linear Regression Results, 1995-2000

	Quadratic	Logistic
Lagged dependent variable	0.214	0.414***
	(1.326)	(4.238)
Book based capital to asset ratio	19.314**	
	(2.454)	
Square of the book based capital to asset ratio	-232.341**	
	(-2.322)	
Logistic function of the book based capital to asset ratio		0.692**
		(2.372)
Observations	7500	750

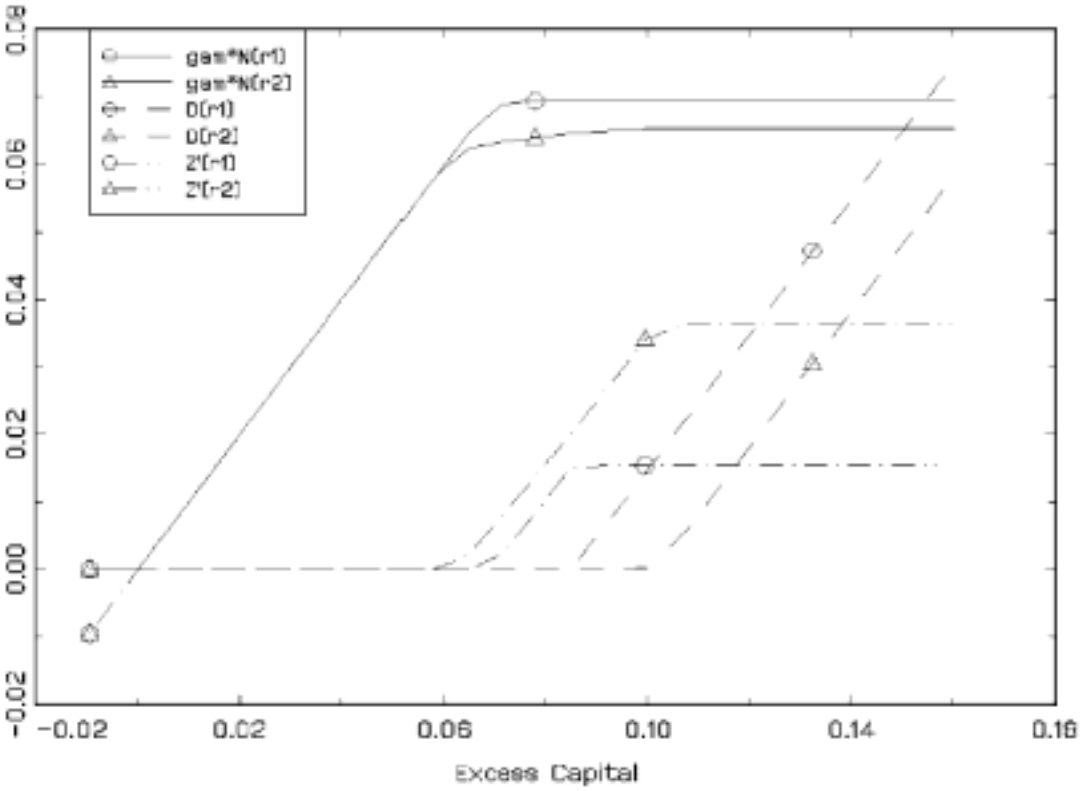
Note
1. The dependent variable is the new lending rate.
2. *, ** and *** show that a coefficient is statistically significant at 10 %, 5% and 1% respectively.
3. t statistics are in parentheses
4. Regressions are run by the 2SLS.

Table 3. Non-linear Regression Results, 1997-2000

	Quadratic	Logistic
Lagged dependent variable	0.422	0.504***
	(3.089)	(4.072)
Book based capital to asset ratio	9.870*	
	(1.838)	
Square of the book based capital to asset ratio	-109.040	
	(-1.648)	
Logistic function of the book based capital to asset ratio		0.543
		(1.554)
Observations	500	500

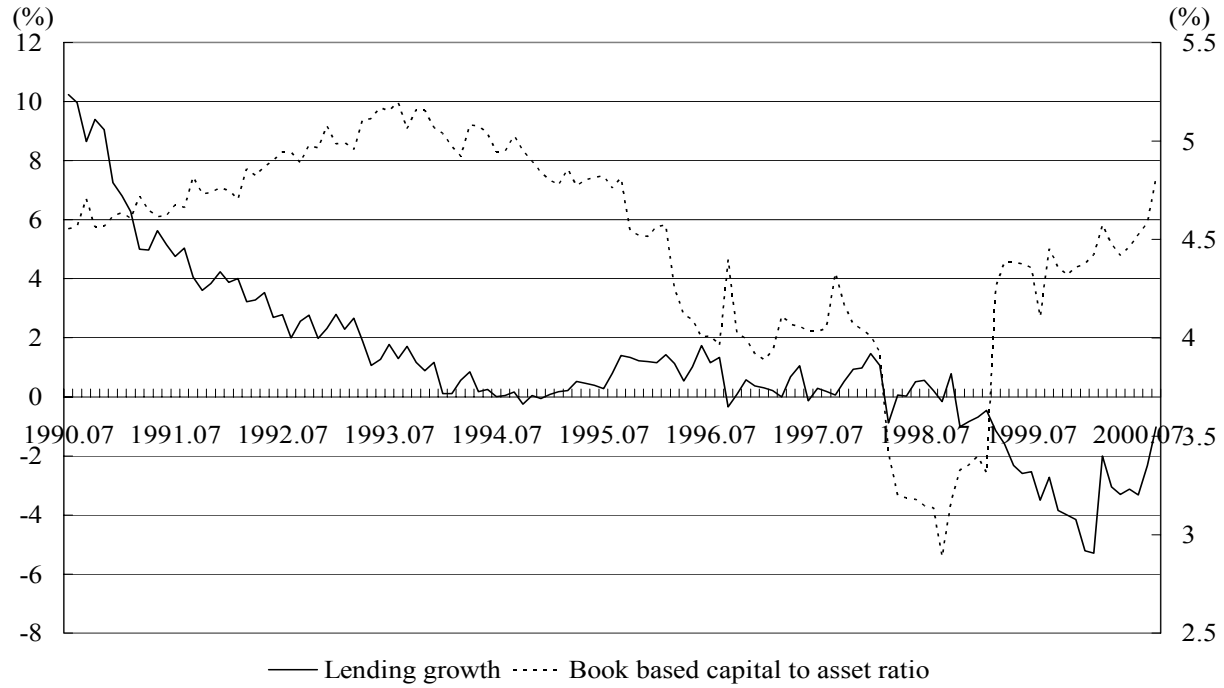
Note
1. The dependent variable is the new lending rate.
2. *, ** and *** show that a coefficient is statistically significant at 10 %, 5% and 1% respectively.
3. t statistics are in parentheses
4. Regressions are run by the 2SLS.

Figure 1. The Simulated New Bank Lending Function



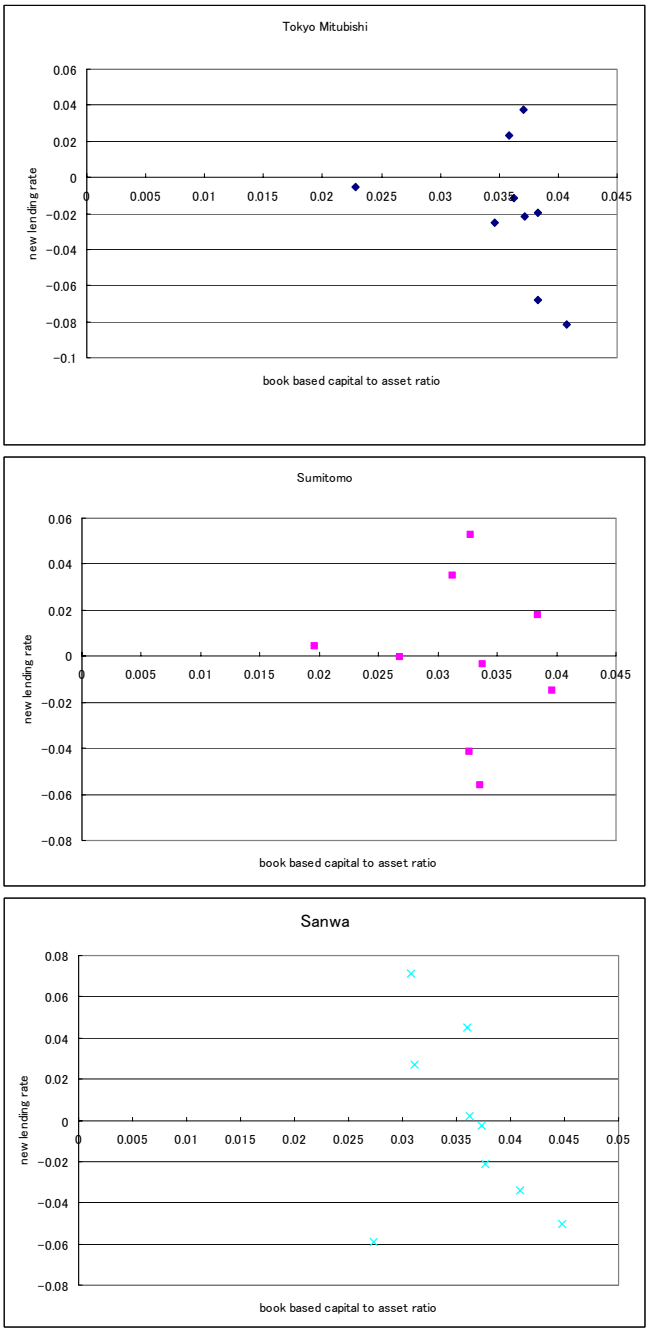
Source: Van den Heuvel (2002)

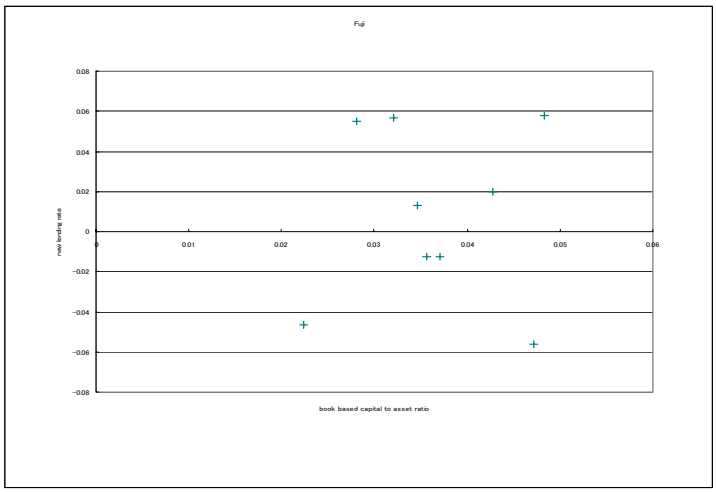
Figure 2. Domestic loan growth and book based capital to asset ratio of domestically licensed banks



Note: The left scale and the right scale measure lending growth and the book based capital to asset ratio respectively.

Figure 3. The Book Based Capital to Asset Ratio and the New Lending Rate
Major City Banks

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0.06
0.04
0.02
0
−0.02
−0.04
−0.06
−0.08
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0.01
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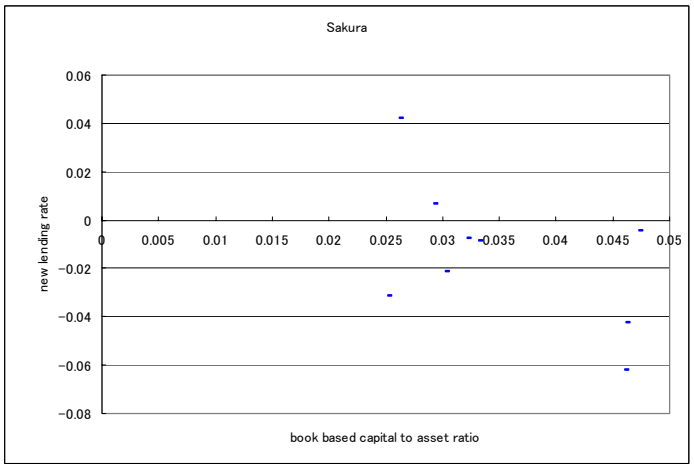
0.04
0.05
0.06
new lending rate
book based capital to asset ratio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0.04
0.02
0
−0.02
−0.04
−0.06
−0.08
0
0.005
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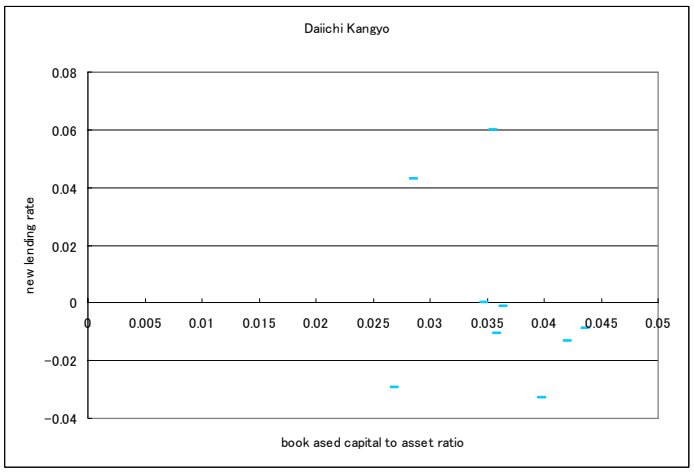
0.02
0.025
0.03
0.035
0.04
0.045
0.05
new lending rate
book based capital to asset ratio


Daiichi Kangyo
0.08
0.06
0.04
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0
−0.02
−0.04
0
0.005
0.01
0.015
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0.025
0.03
0.035
0.04
0.045
0.05
new lending rate
book ased capital to asset ratio

Figure 4. The Book Based Capital to Asset Ratio and the New Lending Rate
Regional (blue colored) and Regional 2 (pink colored) Banks

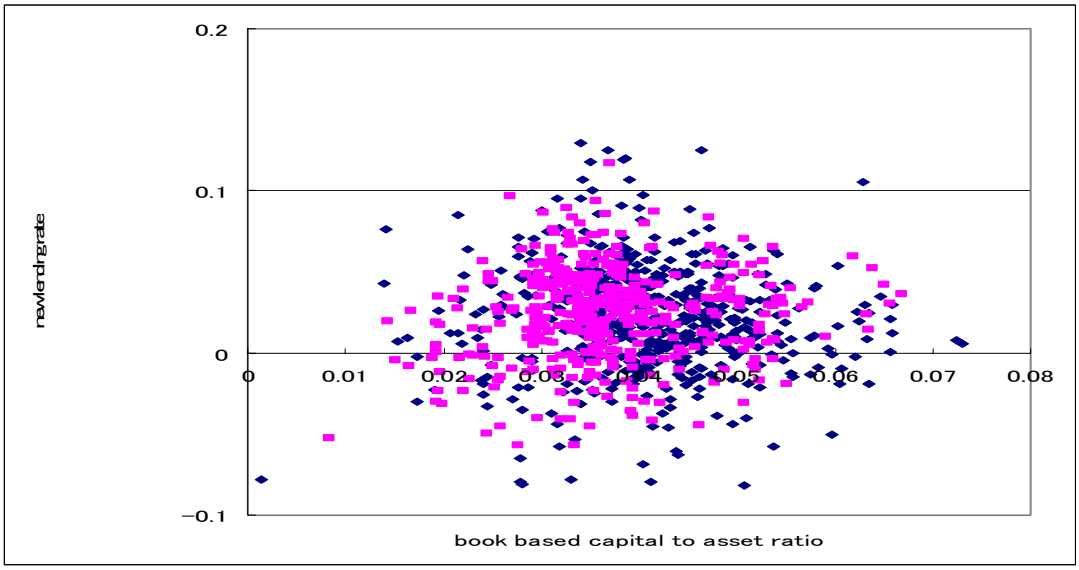
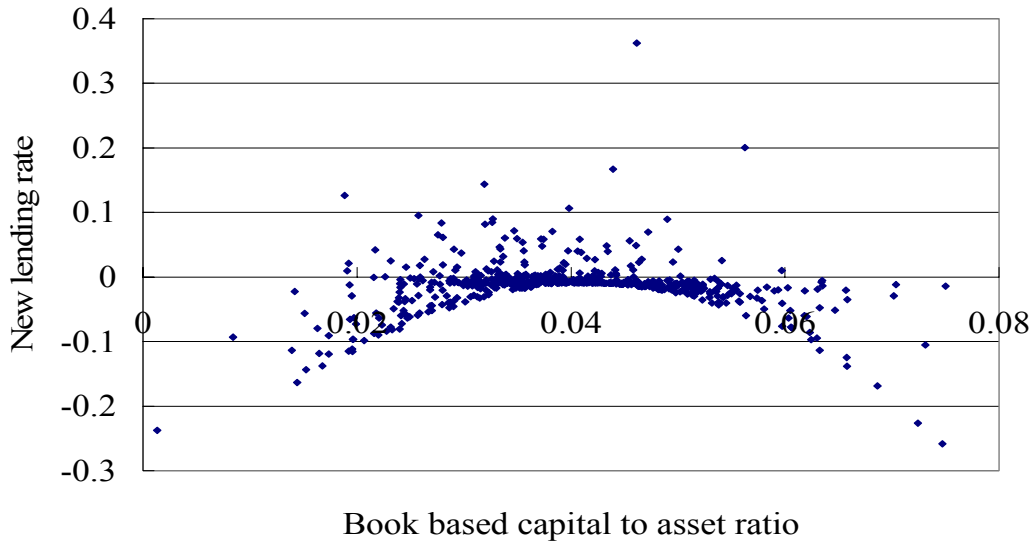
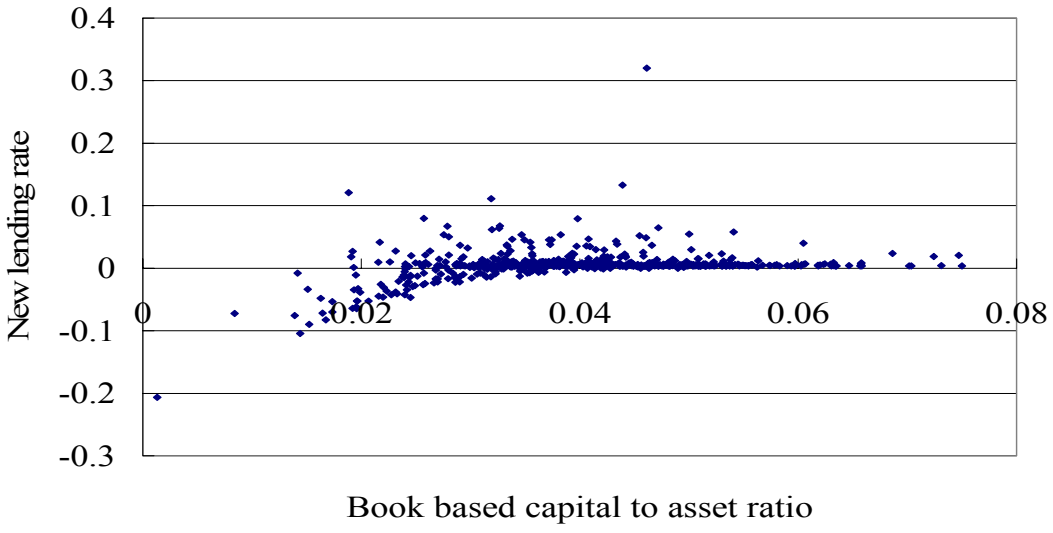


Figure 5. Predicted New Lending Rates, the Quadratic Specification



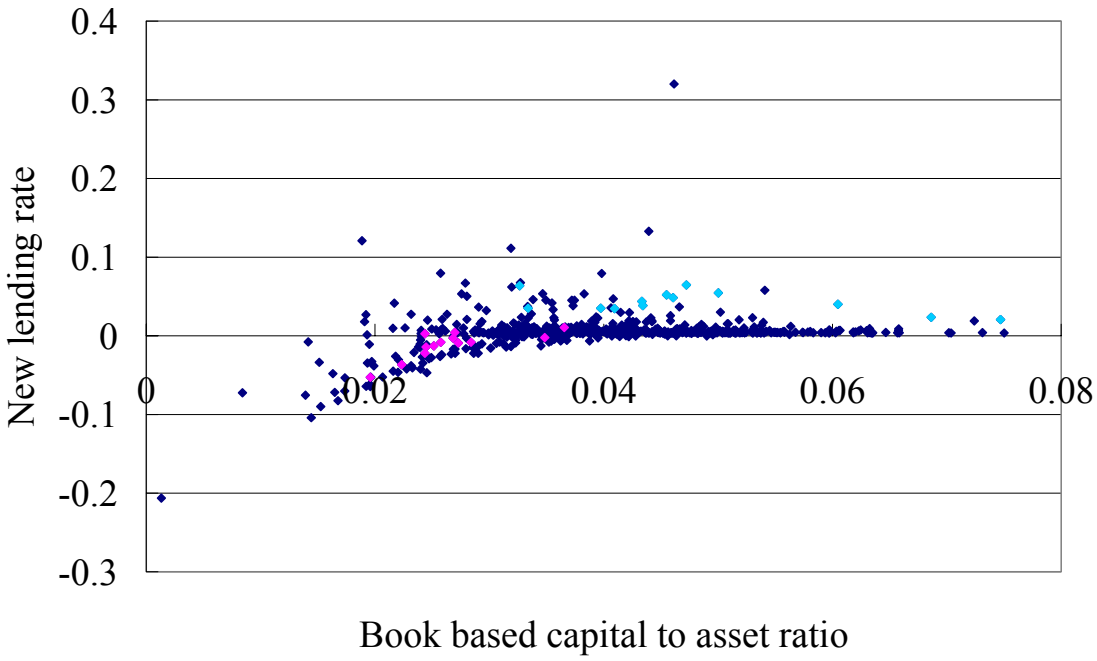
Note
In predicting the (current) new lending rate, the lagged new lending rate is held constant at the sample average of the entire year-bank observations.

Figure 6. Predicted New Lending Rates, the Logistic Specification



Note
In predicting the (current) new lending rate, the lagged new lending rate is held constant at the sample average of the entire year-bank observations.

Figure 7. Predicted Impacts of Public Recapitalization in FY 1998



Note
Publicly recapitalized banks are colored in pink in FY 1997 and in light blue in FY 1998.