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Asymmetric Effects of Monetary Policy: Japanese Experience in the 1990s*

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Abstract

We consider a competitive bank loan market model where the marginal costs of managing and monitoring loans are assumed to increase as borrowers' net worth decreases. We show that the responsiveness of equilibrium bank loan rates to changes in interbank money market rates become weaker as borrowers' net worth decreases. In other words, monetary policy becomes less effective as borrowers' net worth decreases. We test and confirm this prediction by estimating bank loan rate equations using Japanese data. We find that the effectiveness of expansionary monetary policy in the 1990s has been weakened by the deterioration of borrowers' balance sheets, contributing to the long stagnation of the Japanese economy during the period.

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1 Introduction

Since the summer of 1991, the Bank of Japan has been adopting expansionary monetary policy. The BOJ cut its official discount rate, which peaked 6.0 percent in August 1990, nine times until it reached a record low level of 0.5 percent in September 1995. Expansionary monetary policy was pursued further by lowering BOJ's target level of uncollateralized overnight call rate from 0.5 percent to 0.25 percent in September 1998, and finally to zero percent in February 1999.

Despite the BOJ initiatives, the economic activity in Japan has been uncharacteristically weak during most of the 1990s. The growth rate of real GDP has been below 1 percent since fiscal year 1992, except in fiscal years 1995 and 1996 when the Japanese economy temporarily showed a sign of recovery supported by monetary and fiscal stimulus.

Why has the Japanese economy been so weak? It is no doubt that expansionary monetary policy cannot be more than "a drop in the ocean" in the presence of large and persistent negative demand shocks originating from the burst of bubble in stock and land prices. At the same time, we cannot rule out the possibility that expansionary monetary policy has been less effective because of capital tightening in banks and borrowers. For example, practitioners often point out that the lending behavior of banks has not been stimulated significantly by the easy monetary policy, and therefore households and non-financial firms, particularly firms of small and medium-sized which rely heavily on borrowings from banks, have not been enjoying the benefits of the easy monetary policy.

The objective of this paper is to shed some light on how and to what extent the effectiveness of expansionary monetary policy in the 1990s has been weakened by the deterioration of borrowers' balance sheets. In doing so, we focus on the response of banks' lending behavior to monetary policy stimulus and study how it is related with borrowers' net worth.

Consider a non-financial firm which finances a part of its investment by bank borrowing. Under the assumption of asymmetric information between the firm and banks, the firm has to pay agency costs of financing in the form of external finance premium, i.e. the difference in costs between external and internal financing. As pointed out by Bernanke and Gertler (1989) among others, external finance premium depends upon the firm's net worth. Lower net worth of the firm intensifies the agency problem, thereby increasing external finance premium as compensation to banks for the expected increase in evaluation and monitoring costs. Suppose, for example, that the net worth of the firm is held in the form of collateralizable assets such as land. If the fraction of the firm's borrowing covered by collateral decreases, banks require the firm to pay greater external finance premium. In more general terms, the external finance premium is a monotonically decreasing function of borrowers' net worth.

This paper examines more in detail about the functional relationship between the external finance premium and borrowers' net worth. To do so, we start with the assumption that bank loan market is competitive so that the external finance premium is determined by banks' marginal monitoring costs. We then claim that bank loan supply curve becomes steeper as borrowers' net worth decreases. Intuitively speaking, this feature comes from the fact that, as the fraction of borrowing covered by collateral becomes very large, banks' marginal monitoring cost becomes very small or zero and stays at near-zero level even if bank loan increases marginally. In other words, the slope of bank loan supply curve is very small when borrowers' net worth is very large. In contrast, when the firm has very small amount of collateralizable assets relative to borrowing, banks' marginal monitoring cost increases substantially as the firm increases its borrowing marginally.

This observation has an important implication for the effectiveness of monetary policy. That is, the responsiveness of equilibrium bank loan rates to changes in interbank money market rates, central bank's primary policy indicator, depends upon borrowers' net worth; equilibrium bank loan rates become less sensitive to changes in interbank money market rates as borrowers' net worth decreases. This comes from the fact that equilibrium bank loan rates can be expressed as a nonlinear function of firm's net worth and interbank money market rates. The mechanism behind this nonlinear relationship is straightforward: when borrowers' net worth is very high, banks' loan supply curve is almost flat, and as a result, equilibrium bank loan rates change almost one-to-one with interbank money market rates. In contrast, banks' loan supply curve is very steep when borrowers' net worth is very low, and consequently, equilibrium bank loan rates are insensitive to changes in interbank money market rates.

Given the tendency that borrowers' net worth is high in booms and low in recessions, the above observation implies that tight monetary policy in booms works well but easy monetary policy in recessions is not so effective. The effects of monetary policy are asymmetric in this sense. It should be emphasized that this asymmetry stems from the nonlinearity among bank loan rates, interbank money market rates, and firm's net worth.[1]

This paper examines the above observations from the theoretical and empirical viewpoints and derives some implications about the Japanese monetary policy in the 1990s. We basically follow the line of existing researches on the macroeconomic consequences of capital market imperfections, but deviates from it in the following two aspects.

First, the present paper looks for evidences of the asymmetric effects of monetary policy in financial prices, i.e. bank loan rates, which is in sharp contrast with most of the existing studies that look for evidences in financial quantities such as the volume of bank lending.[2][3]

Second, the present paper argues that the responsiveness of equilibrium bank loan rates to changes in interbank money market rates *decreases* as borrowers'

[1] Asymmetric effects of monetary policy have been discussed by many researchers. One source of asymmetry is credit constraints faced by households and firms which augments the impact of tight monetary policy while such effect does not exist in the case of easy monetary policy, as discussed by Tobin (1978). Another source of asymmetry is the downward nominal rigidity of prices and wages as empirically examined by De Long and Summers (1988). According to them, the consequence of tight monetary policy appears as a significant fall in output with little changes in prices while that of easy policy appears as a significant increase in prices and little changes in output. See also Morgan (1993) for more on the general discussion about asymmetric effects of monetary policy.

[2] See Bernanke, Gertler, and Gilchrist (1996) for the survey.

[3] An exception is Kashyap, Stein, and Wilcox (1993) who look at the spread between prime commercial paper rates and Treasury bill rates in order to provide evidences of the bank lending channel of monetary policy transmission.

net worth decreases, while the so-called balance sheet channel model predicts that the responsiveness *increases* as borrowers' net worth decreases.[4] According to the balance sheet channel model, a rise in risk-free interest rates weakens borrowers' balance sheets by decreasing cash flows net of interest and lowering the value of collateral assets, thereby boosting external finance premium. The agency problem, which is at the core of the above mechanism, becomes more severe as borrowers' net worth decreases. Therefore, the above mechanism is likely to be more potent in bad times (when borrowers' net worth is low) than in good times. Note that this prediction seems to be inconsistent with Japanese experience in the 1990s where the burst of bubble in stock and land prices coexists with ineffective easy monetary policy.

The paper begins by considering a model of competitive bank loan market where an equilibrium bank loan rate is determined. Banks are assumed to solve a profit maximization problem where banks' costs depend not only on the amount of loans but also on borrowers' net worth. Our specification of the cost function captures the idea that the marginal cost banks must pay for an additional loan decreases as borrowers' net worth increases. Under this assumption, we show that the responsiveness of equilibrium bank loan rates to changes in interbank money market rates depends on the level of borrowers' net worth; equilibrium bank loan rates become less sensitive to changes in interbank money market rates as borrowers' net worth decreases.

We test this prediction by estimating a bank loan rate equation. The list of independent variables includes the overnight call loan rate and the stock price index as a proxy for borrowers' net worth. A key part of the theoretical prediction is the nonlinear relationship between the bank loan rate and these two independent variables, which is confirmed by regression analysis using the quarterly data running from 1981 to 1997.

The rest of the paper is organized as follows. Section 2 constructs a model of competitive bank loan market and derives some testable implications. Results of

[4] See, for example, Gertler and Hubbard (1988), Gertler and Gilchrist(1994), and Oliner and Rudebusch (1996).

regression analysis are reported in Section 3 and discussed further in Section 4. Section 5 concludes the paper.

2 A Model of Bank Loan Market

We consider a competitive bank loan market where representative bank borrows money in interbank money market and lend it to non-financial firms (see, for example, Freixas and Rochet (1997) for more details about standard models of bank loan market). We assume that banks must pay some costs when they extend loans to firms, including general maintenance costs as well as costs associated with banks monitoring activities. To be more specific, the representative bank pays $C(L, w)$ when it extends loans L to a firm with the net worth of w. The costs depend not only on L but also on w because costs associated with banks' monitoring activities depend on the amount of borrowers' net worth.

We assume that $C(L, w)$ is quadratic in L and satisfies the following standard properties:

$$\frac{\partial C}{\partial L} \geq 0,$$
$$\frac{\partial^2 C}{(\partial L)^2} > 0$$

for $L \geq 0$. A key assumption in our model is that the marginal cost of loans is a decreasing function of borrowres' net worth. Namely,

$$\frac{\partial^2 C}{\partial L \partial w} \leq 0$$

for $L \geq 0$. This is because highly indebted borrowers are more likely to be unable to repay, and therefore banks have to monitor them more carefully. Put differently, lower net worth intensifies the agency problem between banks and borrowers, thereby increasing banks monitoring costs.

Under the above assumptions, $C(L, w)$ can be rewritten, without loss of generality, as

$$C(L, w) = c_0(w) + c_1(w)L + c_2(w)L^2$$

where $c_0(w)$, $c_1(w)$, and $c_2(w)$ are functions of w such that

$$c_1(w) \geq 0, \;\; c_2(w) > 0,$$
$$c_1'(w) = \lim_{L \to 0} \frac{\partial^2 C}{\partial L \partial w} \leq 0,$$
$$c_2'(w) = \lim_{L \to \infty} \frac{1}{2L} \frac{\partial^2 C}{\partial L \partial w} \leq 0.$$

Denote the bank loan rate applied to the firm by i_l and the interbank money market rate by i. We regard i as a control variable of a central bank. Then, we can express the bank's profit as

$$\pi(L) = (i_l - i)L - C(L, w).$$

The first-order condition for profit maximization provides the following inverse supply function of loans:

$$i_l = i_l(L, i, w) = i + \frac{\partial C}{\partial L} = i + c_1(w) + 2c_2(w)L. \tag{1}$$

Note that the concavity of the cost function guarantees the second-order condition.

Differentiating (1) with respect to L and w leads to

$$\frac{\partial i_l}{\partial w} = \frac{\partial C}{\partial L \partial w} = c_1'(w) + 2c_2'(w)L \leq 0, \tag{2}$$
$$\frac{\partial^2 i_l}{\partial w \partial L} = \frac{\partial^3 C}{(\partial L)^2 \partial w} = 2c_2'(w) \leq 0. \tag{3}$$

Equation (2) implies that, as long as $c_2'(w)$ is strictly negative, an increase in w shifts the loan supply schedule outward. Moreover, equation (3) implies that the loan supply schedule becomes flatter as w increases. Put together, the loan supply schedule rotates clockwise as borrowers' net worth increases.

Let the loan demand schedule be $d_l(i_l) = a_0 - a_1 i_l$ where $a_0, a_1 > 0$. Then the equilibrium bank loan rate $i_l^* = i_l^*(i, w)$ satisfies

$$i_l^* = i + \frac{\partial C}{\partial L}(a_0 - a_1 i_l^*, w) = i + c_1(w) + 2c_2(w)(a_0 - a_1 i_l^*). \tag{4}$$

Solving for i_l^*, we obtain

$$i_l^*(i, w) = \frac{i}{1 + 2a_1 c_2(w)} + \frac{c_1(w) + 2a_0 c_2(w)}{1 + 2a_1 c_2(w)}. \tag{5}$$

The following proposition shows the results of comparative statics for equilibrium bank loan rate with respect to borrowers' net worth.

Proposition

1. *Equilibrium bank loan rate decreases as borrowers' net worth increases, i.e.*

$$\frac{\partial i_l^*}{\partial w} \leq 0$$

where strict inequality holds only when $c_1'(w) < 0$ *or* $c_2'(w) < 0$*.*

2. *Equilibrium bank loan rate becomes more sensitive to changes in interbank money market rate as borrowers' net worth increases, i.e.*

$$\frac{\partial}{\partial w}\left(\frac{\partial i_l^*}{\partial i}\right) \geq 0$$

where strict inequality holds only when $c_2'(w) < 0$*.*

Proof. Differentiating (4) with respect to w, we have

$$\frac{\partial i_l^*}{\partial w} = c_1'(w) + 2c_2'(w)L = -2a_1 c_2(w)\frac{\partial i_l^*}{\partial w}$$

and thus

$$\frac{\partial i_l^*}{\partial w} = \frac{c_1'(w) + 2a_0 c_2'(w)L}{1 + 2a_1 c_2(w)}. \tag{6}$$

The first part of the proposition directly follows from (6). Differentiating (5) with respect to i, we have

$$\frac{\partial i_l^*}{\partial i} = \frac{1}{1 + 2a_1 c_2(w)}.$$

Differentiating this expression with respect to w, we have

$$\frac{\partial^2 i_e^*}{\partial w \partial i} = \frac{-2a_1 c_2'(w)}{(1 + 2a_1 c_2(w))^2}. \tag{7}$$

The second part of the proposition directly follows from (7). ∎

If we interpret the difference between bank loan rate and interbank money market rate as external finance premium, the first part of the proposition simply says that the external finance premium depends inversely on the borrowers' net worth. This is the property derived by theoretical studies such as Townsend (1979), Bernanke and Gertler (1989), and Bernanke and Gertler (1990). Bernanke and Gertler (1995) provides an evidence that the spread between the prime rate and the T-bill rate opens up during tight money periods, arguing that this could be interpreted as reflecting a negative correlation between external finance premium and borrowers collateralizeable net worth.

If we regard changes in interbank money market rate as changes in monetary policy, the second part of the proposition can be interpreted as saying that the effectiveness of monetary policy depends on borrowers' net worth. Equilibrium bank loan rate becomes more sensitive to changes in interbank money market rate as borrowers' net worth increases. In this sense, monetary policy is more effective in an economy with larger borrowers' net worth. On the other hand, monetary policy is not so effective when borrowers do not have enough net worth. Given the tendency that borrowers' net worth is high in booms and low in recessions, the above observation implies that tight monetary policy in booms works better than easy monetary policy in recessions.

3 Estimation of Bank Loan Rate Equation

This section tests the predicted relationship between borrowers' net worth and the responsiveness of equilibrium bank loan rate to changes in interbank money market rate. More specifically, we estimate equation (5) to check whether or not the condition $c_2'(w) < 0$ is supported by the data.

We use Japanese quarterly data running from the first quarter of 1981 to the fourth quarter of 1997. First, the series of bank loan rate is taken from *Average Contracted Interest Rates on New Loans and Discounts*, monthly statistics released by the Bank of Japan. This series represents the arithmetic mean of rates on new or newly extended loans and discounts (excluding overdrafts) during the month, covering the financial institutions which have accounts with the Bank of Japan. Second, we use the series of uncollateralized overnight call rate for i. Finally, we use the Nikkei Stock Average as a proxy for firms' net worth based on the assumption that stock price reflects firms' net worth. We divide the Nikkei Average by the nominal GDP for scaling.

3.1 Baseline Result

In estimating equation (5), we must specify the functional form of $c_1(w)$ as well as that of $c_2(w)$. In our baseline regressions, we assume that $c_1(w)$ and $c_2(w)$ are linear in w, i.e.

$$c_1(w) = c_{10} - c_{11}w,\ c_2(w) = c_{20} - c_{21}w$$

where $c_{10}, c_{11}, c_{20}, c_{21} \geq 0$. Plugging $c_1(w)$ and $c_2(w)$ into (5), replacing parameters, and adding an error term, we obtain an estimating equation:

$$i^*_{l,t} = \frac{i_t}{\beta_1 w_t + \beta_2} + \frac{\beta_3 w_t + \beta_4}{\beta_1 w_t + \beta_2} + \varepsilon_t \tag{8}$$

where the assumptions in the previous section implies that $\beta_1 = -2a_1c_{21} \leq 0$, $\beta_2 = 1 + 2a_1c_{20} > 0$, $\beta_3 = -c_{11} - 2a_0c_{21} \leq 0$, and $\beta_4 = c_{10} + 2a_0 = c_{20} \geq 0$. Note that the key prediction of our model, $c_2'(w) = -c_{21} < 0$, is true if $\beta_1 = -2a_1c_{21} < 0$ in the above specification.

We estimate equation (8) by nonlinear least squares. Regression results are presented in Table 1.1. We conduct three sets of regressions, all of which transform the proxy for borrowers' net worth, i.e. the Nikkei Average divided by the nominal GDP, by the Box-Cox function but use different values for λ. The column labeled "$\lambda = 1$" of the table shows the estimated coefficients with t-statistics when we set $\lambda = 1$, namely the Box-Cox transformation is linear. Note that t-statistics reported in the table are asymptotically evaluated. As predicted from the theoretical analysis, β_1 and β_3 are negative while β_2 and β_4 are positive. Also, note that the coefficient of interest, β_1, is significantly different from zero.

In order to check the robustness of the above results, we repeat NLLS regressions for different values of λ, 0 and -1, each of which corresponds to different formulation of borrowers' net worth. Regression results, which are reported on the columns labeled "$\lambda = 0$" and "$\lambda = -1$," are almost the same as those with $\lambda = 1$.

Table 1.2 reestimates equation (8) instrumenting for w and i with nominal government investment, yen/dollar exchange rate, land price index, lagged inflation rates, and lagged overnight call rate. We confirm that regression results do not change significantly.

3.2 Alternative Specification

In the baseline regressions we have assumed that both $c_1(w)$ and $c_2(w)$ are linear in w, but we now try alternative specifications. We assume that $c_1(w)$ and $c_2(w)$ satisfy

$$\frac{1}{1+2a_1c_2(w)} = \beta_1 w + \beta_2, \quad \frac{c_1(w)+2a_0c_2(w)}{1+2a_1c_2(w)} = \beta_3 w + \beta_4$$

where $\beta_1 \geq 0$ and $\beta_3 \leq 0$. Then, by adding a noise term, equation (8) boils down to a simpler functional form:

$$i^*_{l,t} = i_t(\beta_1 w_t + \beta_2) + \beta_3 w_t + \beta_4 = \beta_1 w_t i_t + \beta_2 i_t + \beta_3 w_t + \beta_4 + \varepsilon_t, \tag{9}$$

Note that this equation is nonlinear in variables but linear in coefficients. Thus we do not have to use NLLS any more and successfully avoid asymptotic evaluation of t-statistics. Also, note that the responsiveness of equilibrium bank loan rate to changes in interbank money markets rate does depend on the level of borrowers' net worth as long as β_1 is strictly greater than zero.

Regression results are reported in Table 2.1. All of the estimated coefficients are of correct sign. In particular, the coefficient on the interaction term, β_1, is positive as predicted and significantly different from zero. We obtain similar results even when we use 2SLS in stead of OLS (see Table 2.2).

3.3 Simple Simulation

To get a quantitative idea about how much the effectiveness of easy monetary policy in the 1990s has been damped by declines in borrowers' net worth, Table 3 conducts a counterfactual simulation. We calculate the forecasted values of bank loan rate assuming that the Nikkei Average stays at the peak level (36,500 yen in the fourth quarter of 1989) throughout the 1990s. Simulation results indicate that the bank loan rate would be lower by about 0.8 percentage points if the burst of bubble in stock prices had not occurred. Moreover, it is important to note that we might still underestimate the negative impacts of the burst of bubble on the effectiveness of expansionary monetary policy. Given that the deterioration of borrowers' balance sheets intensifies banks' preference for high-quality customers (i.e. flight to quality), it is probable that the effective cost of funds to a borrower of given quality would be higher than measured by the arithmetic mean of rates on new or newly extended loans.

4 Discussion

4.1 Loan Demand and Borrowers' Net Worth

In the previous two sections, we have assumed that the demand for loans is independent of borrowers' net worth. But one might argue that borrowers with less net worth have less ability to take risks and thus reduce the volume to borrow. If this is the case, loan demand should depend upon borrowers' net worth.

To see how the proposition in Section 2 would change when loan demand depends on borrowers' net worth, let us denote the new loan demand schedule by $d_l(i_l, w) = a_0(w) - a_1 i_l$ where $a_0'(w) \geq 0$ and $a_1 > 0$. Then the equilibrium bank loan rate i_l^* satisfies

$$i_l^* = i + c_1(w) + 2c_2(w)d_l(i_l^*, w) = i + c_1(w) + 2c_2(w)(a_0(w) - a_1 i_l^*) \tag{10}$$

and thus

$$i_l^* = \frac{i}{1 + 2a_1c_2(w)} + \frac{c_1(w) + 2a_0(w)c_2(w)}{1 + 2a_1c_2(w)}. \tag{11}$$

Note that the above two equations correspond to (4) and (5), respectively.

Differentiating (10) with respect to w, we have

$$\frac{\partial i_l^*}{\partial w} = c_1'(w) + 2c_2'(w)L + 2a_0'(w)c_2(w) - 2a_1c_2(w)\frac{\partial i_l^*}{\partial w}$$

and thus

$$\frac{\partial i_l^*}{\partial w} = \frac{c_1'(w) + 2c_2'(w)L + 2a_0'(w)c_2(w)}{1 + 2a_1c_2(w)}. \tag{12}$$

Since $c_1'(w) + 2c_2'(w)L \leq 0$ and $2a_0'(w)c_2(w) \geq 0$, the left hand side of (12) can be negative or positive. However, if $|a_0'(w)|$ is small enough, the left hand side of (12) is negative, which is the same property we have observed in the first half of the proposition in Section 2.

Differentiating (11) with respect to w, we have

$$\frac{\partial^2 i_l^*}{\partial w \partial i} = \frac{-2a_1 c_2'(w)}{(1 + 2a_1 c_2(w))^2} \geq 0, \tag{13}$$

which means that the second half of the proposition in Section 2 still holds even if we assume that the loan demand schedule depends on borrowers' net worth.

To check the robustness of our empirical analysis in Section 3, Table 4 estimates bank loan rate equations whose specification is now based on equation (11) assuming again that $c_1(w)$ and $c_2(w)$ are linear in w. The estimating equation is

$$i_{l,t}^* = \frac{i_t}{\beta_1 w_t + \beta_2} + \frac{\beta_3 w_t + \beta_4 + \beta_5 w_t^2}{\beta_1 w_t + \beta_2} + \varepsilon_t.$$

The assumptions predict that $\beta_1 \leq 0$, $\beta_2 > 0$, $\beta_3 \leq 0$, $\beta_4 \geq 0$, and $\beta_5 \leq 0$.

Regression results show that all of the estimated coefficients are of the same sign as predicted. In particular, the coefficient of our interest, β_1, is negative as predicted and significantly different from zero. The above exercise confirms that our claim that the responsiveness of bank loan rates depends upon borrowers' net worth is still supported by data even if bank loan demand depends upon borrowers' net worth.

4.2 Capital Tightening in Borrowers or in Banks?

One of the most important characteristics of the Japanese economy in the 1990s is that capital tightening occurred not only in borrowers (firms and households) but also in banks. As demonstrated by Holmstrom and Tirole (1997), capital tightening in banks raises bank loan rates, or more precisely, the spread between bank loan rate and risk-free rate. Therefore, it might be possible to interpret the ineffectiveness of easy monetary policy in Japan during the 1990s as caused by capital tightening in banks rather than in borrowers as we have discussed. In fact, practitioners often point out that such "capital crunch" has been a serious problem particularly for Japanese banks which are allowed to include 45 percent of unrealized capital gains on stocks into their tier 2 capital. According to them, the burst of bubble in stock prices has deteriorated Japanese banks' balance sheets substantially, thereby creating a serious capital crunch problem.

Although this is a popular argument among practitioners, there are only a few academic papers conducting serious empirical analysis and evidences are mixed. For example, some studies using aggregated time-series data provide evidences consistent with the story that bad loans created by the burst of bubble have prevented Japanese banks from making new loans to firms (Bayoumi (1998) and Motonishi and Yoshikawa (1998)). While these studies do not explicitly discriminate between capital shortage in borrowers and in banks, Woo (1998) attempts to do so by using banks panel data: 79 banks, March 1990 to March 1998. Surprisingly, Woo fails to find any clear evidence of capital crunch for most of the 1990s except 1997 when two big financial failures, Hokkaido Takushoku Bank and Yamaichi Securities, occurred. Other studies investigating the existence of capital crunch in Japan using banks microdata include Ueda (1993) and Ito and Nagataki-Sasaki (1998), both of which focus on the effect of the introduction of capital adequacy requirement in March 1993 on banks lending. These studies find that while the introduction of the capital requirement had a negative impact on the lending behavior of city banks, no such strong impact was observed for other banks including regional banks.

One potential way to discriminate between the two kinds of capital tightening within our empirical framework is to compare the movements of firms' cost of funds for various forms of financing. Cost of funds should rise for all forms of financing if borrowers' capital contract, while it should rise only for bank borrowing if the capital shortage occurs on the side of banks. Unfortunately, however, this methodology is not powerful enough to discriminate between the two in our sample period during which banks' and borrowers' capital tend to comove quite closely: in particular, both bank capital and firm capital contract substantially in the 1990s.

However, it is still possible to say something about the relative importance of capital crunch by examining the stability of estimated coefficients. If capital crunch has a substantial influence on banks' lending behavior, the estimated coefficients should be unstable. Based on this understanding, we conduct CUSUM test as well as CUSUMSQ test[5] for equation (9) to find that the null hypothesis (the estimated equation is stable) is not rejected at the significance level of 5 percent. In this sense

[5]See Brown, Durbin, and Evans (1975).

we fail to find strong evidence in our sample period that capital crunch, if it exists, seriously distorts the results of empirical analysis in Section 3.

4.3 Balance Sheet Channel of Monetary Policy Transmission

Theoretical analysis in Section 2 is based on the assumption that borrowers' net worth, w, is exogenously given. However, it is often pointed out that one of the major factors to determine prices of collateralizeable assets as well as cash flows net of interest is monetary policy. For example, Bernanke and Gertler (1995) maintains that the crash of stock and land prices in late 1980s and early 1990s in Japan was the result (at least in part) of monetary tightening. Based on this understanding, many researchers emphasize the importance of the so-called balance sheet channel of monetary policy transmission: a rise in interbank money market rates weakens borrowers' balance sheets, increases external finance premium, and creates recessions. Kwon (1998) argues that this channel of monetary policy transmission plays an important role particularly in Japan where a relatively large fraction of business investment is financed by collateralized bank loans.

How does our theoretical analysis in Section 2 change by taking into consideration the balance sheet channel of monetary policy transmission?

To investigate this, let us now assume that w depends upon i, and express this relationship by $w(i)$ where $w'(i) < 0$. Plugging $w(i)$ into the equilibrium bank loan rate derived in Section 2, $i_l^*(i, w)$, we can express the equilibrium loan rate as a function of i. The first derivative of this function is given by

$$\frac{di_l^*}{di} = \frac{d}{di} i_l^*(i, w(i)) = \frac{\partial i_l^*}{\partial i} + \frac{\partial i_l^*}{\partial w} w'.$$

The first term of the right hand side of the equation represents the responsiveness of bank loan rates to changes in interbank money market rates when the value of borrowers' net worth is kept constant. On the other hand, the second term represents the balance sheet channel of monetary policy transmission.

In order to study the relationship between the responsiveness of bank loan rates and borrowers' net worth, we partially differentiate the above with respect to w:

$$\frac{\partial}{\partial w}\left(\frac{di_l^*}{di}\right) = \frac{\partial^2 i_l^*}{\partial i \partial w} + \frac{\partial^2 i_l^*}{\partial w^2} w'. \tag{14}$$

If (14) is positive, it means that the second half of the proposition in Section 2 still holds even if we take into consideration the balance sheet channel of monetary policy. That is, the responsiveness of equilibrium bank loan rate to changes in interbank money market rate depends inversely on borrowers' net worth.

To study under what condition our claim holds, we differentiate equation (4) twice to get

$$\frac{\partial^2 i_l^*}{\partial w^2} = \frac{1}{1 + 2a_1 c_2(w)} \left(c_1''(w) + 2c_2''(w)L - 4a_1 c_2'(w) \frac{\partial i_l^*}{\partial w} \right).$$

Plugging this into (14),

$$\frac{\partial}{\partial w}\left(\frac{di_l^*}{di}\right) = \frac{\partial^2 i_l^*}{\partial i \partial w} - \frac{4a_1 c_2'}{1 + 2a_1 c_2} \frac{\partial i_l^*}{\partial w} w' + \frac{c_1'' + 2c_2'' L}{1 + 2a_1 c_2} w'. \tag{15}$$

The first term of the right hand side is positive, which is shown in the second half of the proposition in Section 2. The second term is also positive because $c_2' < 0$, $w' < 0$, and

$$\frac{\partial i_l^*}{\partial w} < 0,$$

where the last inequality follows from the first half of the proposition in Section 2. The sign of the third term, however, can be positive or negative depending on the values of c_1'' and c_2''. If both c_1'' and c_2'' are positive and very large, the third term is negative with very large absolute value, and as a result, (15) could be negative, implying that our claim is no longer true. Otherwise, the first and second terms dominate the third term, so that (15) becomes positive. If this is the case, a negative relationship between the responsiveness of bank loan rates and borrowers' net worth still holds. For example, if we specify the functional form of c_1 and c_2 as in Section 3.1, then $c_1'' = 0$ and $c_2'' = 0$, and thus the third term disappears. If we specify the functional form as in Section 3.2, we obtain the following by directly differentiating (9):

$$\frac{\partial}{\partial w}\left(\frac{di_l^*}{di}\right) = \frac{\partial^2 i_l^*}{\partial i \partial w} + \frac{\partial^2 i_l^*}{\partial w^2} w' = \frac{\partial^2 i_l^*}{\partial i \partial w} = \beta_1 > 0.$$

Using U.S. data, Gertler and Gilchrist (1994) find that the response of small firms to changes in federal funds rates is asymmetric over the cycle: stronger in bad times (when borrowers net worth is low) than in good times. They argue that this is because a decline in borrowers' net worth intensifies the agency problem, thereby enhancing the balance sheet channel of monetary policy transmission. Their findings suggest that the expression on the left hand side of equation (14) could be negative. In the case of Japanese economy in the 1990s, however, borrowersf balance sheet problem and ineffectual easy monetary policy coexists, which provides a strong evidence against it.

5 Conclusion

Why has the economic activity in Japan been so weak during the 1990s in spite of expansionary monetary policy? To give an answer to this question, we have constructed a bank loan market model where the marginal costs of managing and monitoring loans is assumed to increase as borrowers' net worth decreases. Using the model, we have shown that the responsiveness of equilibrium bank loan rates to changes in interbank money market rates (central bank's primary policy indicator) become weaker as borrowers' net worth decreases. In other words, monetary policy becomes less effective as borrowers' net worth decreases. This is in stark contrast with the prediction from the balance sheet channel model that a decline in borrowers' net worth intensifies the agency problem, thereby enhancing the balance sheet channel of monetary policy transmission.

We have tested and confirmed the prediction of our model by estimating bank loan rate equations using Japanese quarterly data, 1981 to 1997. We have found that the bank loan rate would be lower by about 0.8 percentage points if the burst of bubble in stock and land prices had not occurred. In this sense the effectiveness of expansionary monetary policy conducted by the Bank of Japan in the 1990s has been substantially weakened by the deterioration of borrowers' balance sheets, contributing, by some extent, to the long stagnation of the Japanese economy during the period.

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TABLE 1.1

BASELINE REGRESSIONS: NLLS

	$\lambda=1$		$\lambda=0$		$\lambda=-1$	
	Estimate	*t*-statistics	Estimate	*t*-statistics	Estimate	*t*-statistics
β_1	-0.5905	-2.708	-0.3565	-2.749	-0.8862	-2.574
β_2	1.0997	10.035	1.1403	12.032	1.0662	8.447
β_3	-3.8751	-3.082	-2.2854	-2.954	-5.9948	-3.092
β_4	0.5754	0.935	0.8805	1.630	0.2961	0.423
Adjusted R^2	0.963		0.962		0.964	
SER	0.347		0.350		0.343	

Notes:
(1) Sample period is 1981Q1 to 1997Q4.
(2) λ is a parameter of the Box-Cox transformation: $w(\lambda) = \{(\text{Nikkei Average/GDP})^{\lambda}\}/\lambda$.

TABLE 1.2

BASELINE REGRESSIONS: NL2SLS

	$\lambda=1$		$\lambda=0$		$\lambda=-1$	
	Estimate	*t*-statistics	Estimate	*t*-statistics	Estimate	*t*-statistics
β_1	-1.1612	-4.061	-0.9244	-3.738	-1.8796	-3.985
β_2	0.7996	6.004	0.8744	7.231	0.6934	4.314
β_3	-6.5232	-3.939	-5.6388	-3.664	-10.5291	-3.892
β_4	-0.8377	-1.097	-0.5793	-0.813	-1.4478	-1.567
Adjusted R^2	0.952		0.923		0.947	
SER	0.397		0.368		0.418	

Notes:

(1) Sample period is 1981Q1 to 1997Q4.

(2) λ is a parameter of the Box-Cox transformation: $w(\lambda)= \{(\text{Nikkei Average/GDP})^{\lambda}\}/\lambda$.

(3) List of instrumental variables: nominal government investment, foreign exchange rate, foreign price, land price, call rate (-1), growth rate of WPI (-1).

TABLE 2.1

ALTERNATIVE SPECIFICATION: OLS

	$\lambda=1$		$\lambda=0$		$\lambda=-1$	
	Estimate	*t*-statistics	Estimate	*t*-statistics	Estimate	*t*-statistics
β_1	0.3272	2.371	0.1854	2.408	0.5007	2.190
β_2	0.8821	12.195	0.8515	14.324	0.9036	10.430
β_3	-2.1419	-2.674	-1.1860	-2.539	-3.4257	-2.651
β_4	0.71724	1.774	0.9396	2.783	0.5244	1.092
Adjusted R^2	0.962		0.959		0.963	
SER	0.348		0.364		0.345	

Notes:

(1) Sample period is 1981Q1 to 1997Q4.

(2) λ is a parameter of the Box-Cox transformation: $w(\lambda)=\{(\text{Nikkei Average/GDP})^{\lambda}\}/\lambda$.

TABLE 2.2

Alternative Specification: Instrumaental Variable Method

	$\lambda=1$		$\lambda=0$		$\lambda=-1$	
	Estimate	*t*-statistics	Estimate	*t*-statistics	Estimate	*t*-statistics
β_1	0.7201	3.565	0.3665	3.356	1.2951	3.572
β_2	1.0956	10.463	1.0004	12.131	1.2098	8.866
β_3	-3.8855	-3.309	-2.0367	-3.055	-6.8687	-3.390
β_4	-0.2259	-0.385	0.2653	0.561	-0.8191	-1.095
Adjusted R^2	0.955		0.957		0.953	
SER	0.382		0.375		0.395	

Notes:

(1) Sample period is 1981Q1 to 1997Q4.

(2) λ is a parameter of the Box-Cox transformation: $w(\lambda)=\{(\text{Nikkei Average/GDP})^{\lambda}\}/\lambda$.

(3) List of instrumental variables: nominal government investment, foreign exchange rate, foreign price, land price, call rate (-1), growth rate of WPI (-1).

TABLE 3
COUNTER FACTUAL SIMULATION

	Bank Loan Rate in 1996		Bank Roan Rate in 1997	
	Baseline specification	Alternative specification	Baseline specification	Alternative specification
Forecast	2.11%	2.10%	2.25%	2.25%
Simulation	1.33%	1.40%	1.38%	1.44%
Difference	0.78%	0.69%	0.88%	0.81%

Notes:

(1) "Simulation" represents the forecasted values of bank loan rate under assumption that the stock price stays at the peak level. (36,500 yen in 1989Q4) throughout 1990s.

(2) NLLS and OLS results (λ=1) are used.

TABLE 4

ALTERNATIVE SPECIFICATION FOR BANK LOAN DEMAND: NLLS

	λ=1		λ=0		λ=-1	
	Estimate	*t*-statistics	Estimate	*t*-statistics	Estimate	*t*-statistics
β_1	-0.4426	-2.073	-0.20972	-1.493	-0.9033	-2.851
β_2	1.2294	10.784	1.1893	12.385	1.0286	8.956
β_3	-6.5636	-5.315	-3.0958	-4.162	-11.3757	-5.665
β_4	0.3426	0.6173	0.8645	1.690	-0.2328	-0.377
β_5	-4.9305	-3.871	-1.3865	-2.923	-11.2396	-4.061
Adjusted R^2	0.969		0.966		0.971	
SER	0.313		0.340		0.308	

Notes:
(1) Sample period is 1981Q1 to 1997Q4.
(2) λ is a parameter of the Box-Cox transformation: $w(\lambda) = \{(\text{Nikkei Average/GDP})^{\lambda}\}/\lambda$.