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The Determination of the Call Rate in Japan

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Foreword

As it is often said, the shor-term money market interest rate, especially the call rate is most sensitive to money market conditions, and moreover, it reflects the stance of monetary policy by the Bank of Japan. BOJ, if necessary, can cause the call rate, particularly the rate applicable to unsecured overnight loan, by means of its routine operations. In this sense, the call market is usually a "mirror" of money markets, and a "field" in which ways and means of BOJ to make adjustments can be seen. As such, it is very important for us to understand how and in what process the call rate is determined.

Nevertheless, it cannot be said that so far we have a satisfactory consensus as to these matters of fundamental importance in the understanding of mechanism that determines the call rate and by which monetary policy is being applied in Japan. In fact, we still see a good deal of discussions going on concerning the subject[1]. As it is, the present paper has been developed as a critical study of existing theories on determination mechanism of the call rate.

In the first section, I see the mechanism used by the U. S. Federal Reserve Bank (FRB) to regulate money market rates as a part of the monetary policy in a wide rsense. Major theories regarding the comparable mechanism used in Japan

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1) A few years ago, in the "Tokyo Keizai Weekly", Kikuo Iwata and Kunio Okina debated actively, on the mechanism determining the money market interest rates. See Iwata (1993) and Okina (1993).

are reviewed in some detail in the second section. In the third section, I make a series of empirical analyses of Japanese banks' reserves under the reserve requirement system and of loans provided by BOJ to banking institutions. These two play an important role in determination of the call rate. The analysis is also a critical examination of those prevailing theories and classifications concerning major characteristics of how money market rates are determined in Japan. Following these discussions, some basic conclusions are given.

I U. S. Money Market Model

In the United States, emergence of inflation in 1970's caused the U. S. monetary authorities to introduce two major changes in their operating procedures. The first involved a shift from use of the federal fund rate (FF rate) as the target of operation to utilize non-borrowed reserves instead, while the second change, which was adopted in October 1982 was to make borrowed reserves as the target instead of non-borrowed reserves. Yet, in spite of these important changes in the FRB's operating procedure, the U. S. mechanism of money market rates determination remains basically the same. The core rate among a variety of U. S. money market rates is the overnight rate (the rate applied to a loan which must be settled on the immediately following day of business), or the FF rate as a matter of fact. The mechanism determining the FF rate can be explained using a fairly simple model as follows[2]:

$$TR_D = RR + ER = a_0 - a_1 r_f \quad (1)$$

$$TR_s = NBR + BR \quad (2)$$

$$BR = b_0 + b_1 (r_f - r_b) \quad (3)$$

where if $r_f \geqq rb$, then $b_1 > 0$ and if $r_f < r_b$, then $b_1 = 0$

$$TR_D = TR_S \quad (4)$$

The equation (1) represents the demand for total reserves of all the banking sector, and it is a declining function of the FF rate (r_f). As it is well known, total reserves consist of required reserves (RR) and excess reserves (ER), and this model assumes that required reserves are fixed and excess reserves are negatively dependent on the FF rate as the opportunity cost.

On the other hand, the equation (2) represents the source of the reserve supply to the entire banking sector. The total reserves consist of non-borrowed reserves (NBR), which can be a policy variable under FRB control, and of borrowed reserves (BR) which are available from the discount window of FRB. The equation (3) means that the balances of borrowing from FRB by the entire banking sector depend on the spread between the FF rate and the discount rate (r_b), and also that borrowing from FRB increases as the spread grows[3]. Lastly, the equation (4) represents

2) We owe the following model to Thornton (1988), but the model is common to many others including Hetzel (1981, 1982), Wallich (1984) and so on. A smart explanation of the U.S. interest setting mechanism is also seen in Kanzaki (1988).

3) For a recent trend of the Federal Reserve Bank lending, see Pearce (1993) and Ichikawa (1994).

the demand equals the supply for the total reserves.

If both of non-borrowed reserves and the discount rate, as policy variables, are set at a fixed level, the equilibrium FF rate can be obtained as follows:

$$r_f = -\lambda^{-1}[NBR - b_1 r_b + (b_0 - b_1)] \tag{5}$$

where $\lambda = a_1 + b_1$

The equation (5) means that by applying direct control over non-borrowed reserves by means of open market operations, or by influencing borrowed reserves by means of the discount rate, the Federal Reserve Bank can actually move the FF rate to a desired level.

Now, let us consider a case in which FRB has cut down the reserve supply in order to push up the FF rate. Figure 1 outlines how this operation works.

In this figure, TR_D represents the demand for total reserves by the entire banking sector. The FF rate can be taken as the opportunity cost of carrying excess reserves, and for this reason, it is given as the curve which is declining to the right side in relation to the FF rate. On the other hand, TR^1_S is the initial reserve supply curve. If the FF rate comes below the discount rate, there is no incentive for borrowing from FRB, and thus the curve is vertical at NRB_1, but it starts to go up towards right as the FF rate moves above the discount rate and borrowing from FRB increases. Once both the demand curve and the supply curve for total reserves are given, the FF rate become fixed at the r^1_f level where the demand for and supply of reserves are balanced.

Then, suppose that FRB has caused non-borrowed reserves to decrease from NBR_1 to NBR_2 by means of open market operations. As a result, the reserve supply curve shifts from TR^1_S to TR^2_S, pushing up the equilibrium FF rate from r^1_f to r^2_f.

In this process of inducing the FF rate to a higher level, any change in lending stance of FRB plays a very important part. If it uses selling operation to curb the supply of non-borrowed reserves, banks will have to depend more on borrowing from

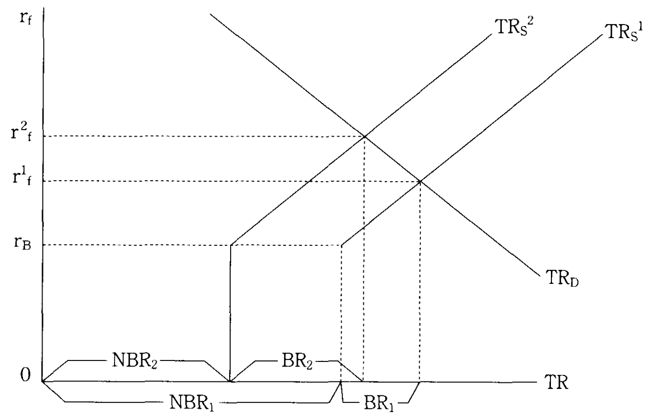

Fig. 1 FF Rate Determination Mechanism

FRB in order to maintain their reserves at a required level, and this causes borrowed reserves to increase. In this process, FRB strengthens their surveillance toward banks and their pressure to induce repayment, causing the banks to depend more on borrowing from the FF market and hence the FF rate to go up. Conversely, FRB may push down the FF rate by using buying operations to cause increase of non-borrowed reserves, which make banks less dependent on FRB and ease the demand-supply relationship at the FF market.

We can see, therefore, that the mechanism which the U. S. Federal Reserve Bank uses to induce shift of money market rates based upon two conditions: first, banks are holding excess reserves which are sensitive to change in the FF rate, and second, any increase or decrease of borrowing from FRB causes a change in the demand-supply relationship at FF market.

II Japanese Money Market Model

The FF rate is the most representative of the overnight interest rate in the United States. It is determined by the way banking institutions behave as demander in the reserve market in one part and by the way FRB behaves as the sole supplier of bank reserves. The idea that the FF rate is determined through the process of demand-supply equilibrium of reserves has long been the traditional and orthodox view held by those who are involved with the system, and it may be called the nucleus of the "FRB theory". According to this theory, the FF market and the reserve market make up a pair and the FF rate represents the "price for reserves".

In Japan, the call market is where individual banks make adjustments of their reserves. It functions as the loan market of reserve deposits (deposits at the central bank) among banking institutions and in this regard it is not basically different from the U. S. FF market. It will be reasonable then to think that the same mechanism is at work in both U.S. and Japanese market. As the first step to prove this, let us take up the balance sheet of the Bank of Japan,as the sole supplier of reserves, to see what are the factors influencing reserves held by the entire banking sector. Table 1 represents a simplified BOJ balance sheet, and we can develop the following equation:

$$TR=BR+BS-(CU+DG-FA) \tag{6}$$

This equation indicates all of the factors causing change in the balance of reserves held by banking institutions. In other words, the balance of reserve deposits held by the entire banking sector fluctuates through three channels: (1) extending and retracting of credit by BOJ, (2) issuance and recovery of bank notes, and (3)

Table 1 BOJ Balance Sheet

BOJ loan (BR)	Bank notes (Cu)
Bills and national bonds (BS)	Reserve deposit (TR)
Overseas assets (FA)	Government deposit (DG)

payment and receipt of treasury funds, including those arising in the foreign exchange account. We can readily see that each of the items on the right side of the equation corresponds to one of these three factors[4].

If we assume that the Japanese call rate is determined in the same way as the FF rate in the United States, then the above equation (6) can be rewritten as:

$$TR(r_c)=BR(r_c-r_b)+[BS-(CU+DG-FA)] \quad (7)$$

where TR'<0 and BR'>0

This equation is written so that it corresponds to the U. S. money market model, since its left side, representing demand for reserves, is assumed to be a declining function of the call rate (r_c), while supply of reserves, shown on the right side, is made up of the portion of reserves supplied by BOJ lending (borrowing from BOJ), expressed by the first term and of the portion supplied by other means, expressed by the second term. Loans made by the Bank of Japan (BR) is the increasing function in regard of the spread between the call rate and the discount rate, but it is possible to consider that the balance of operations (BS) is a policy variable and the portion corresponding to autonomous changes in the market factor (CU+DG−FA), is given to BOJ.

The key issue here is whether or not the equation (7) can apply to Japanese case too, and we must say that the prevailing opinion is negative. The main reason for this is that as Kuroda (1988), as well as Suzuki, Kuroda and Shirakawa (1988) pointed out, the amount of excess reserves held by Japanese banks are so small that their demand for reserves is insensitive to market interest rates. In almost all models explaining the behavior of Japanese banks, reserves held by banks are treated as a constant percentage of total deposit balances, and so far no particular attention has been given to bank reserves (see Horiuchi (1980)).

Yet, it may be argued that even if the demand for reserves is inflexible to market interest rates, there can be the case in which the reserve supply fluctuates in line with interest rates. As seen from equation (7), BOJ loan is shown in the curve moving up towards the right side in relation to the call rate, and this particular aspect should justify some elaboration in view of the prevailing conventional theory.

It is generally held and understood that BOJ rations credit at its own discretion and that the rationing is made on individual basis. According to this view, what is important is the relative levels of the discount rate and the call rate (or money market rates) which represents costs of alternative financing to a bank experiencing a temporary shortage of funds. If the discount rate is consistently lower than the call rate, then it shows that total balance of credit supplied by BOJ is controlled at its discretion. In such a situation, a change in the discount rate cannot have any effect on money market interest rates and on the individual banking behavior, apart from the announcement effect[5].

This majority view assumes that the marginal cost of BOJ borrowing is equal

4) See Furukawa (1992) for details.

5) See Royama (1971).

to the discount rate, which is constant. However, it is perfectly possible for BOJ to strengthen its surveillance or monitoring of individual banks by way of "daily guidance of financial position" if the loan tends to increase to an excessive level, inasmuch as BOJ does rations reserve credit not collectively but on individual basis. Thus, BOJ can make it clear to the bank in question that the effective cost of funds is likely to go up. This means that the discount rate is not necessarily the only effective cost for BOJ borrowing and that the latter may include those impecuniary surveilance cost. We can assume, therefore, that the marginal surveillance cost tends to increase as BOJ borrowing grows[6].

On this assumption, the total cost of BOJ borrowing (TC) can be expressed as follows:

$$TC = r_b \cdot BR + C(BR);\ C' > 0,\ C'' > 0 \tag{8}$$

In this equation, the first right side term represents the discount rate as a cost of borrowing (r_b is the discount rate and BR is balance of BOJ borrowing). The second term (C) stands for the surveillance cost which grows along with the increase of BOJ borrowing. For individual banks, BOJ borrowing and supply of funds from the call market constitute alternative source of funds. As it is, the optimum solution for a bank is to determine BOJ borrowing so that the its marginal cost, derived from the equation (8), is equal to the marginal cost of funds supplied by the money market (the call rate). Therefore, the optimal balance of BOJ borrowing for a bank depends on the spread between the call rate and the discount rate as the increasing function of it:

$$BR = BR(rc - rb);\ BR' > 0 \tag{9}$$

This corresponds to the equation (7). This line of reasoning, that in the process of continuous borrowing from the central bank, some kind of implicit cost is added to the discount rate, is the dominant view which resulted from a great deal of arguments during a long history of U. S. Federal Reserve Bank. Whether or not this view is appropriate in Japan also remains a question, and we now have a problem that the nature of the implicit cost of BOJ borrowing is literally "implicit" and quite ambiguous.

Even since the establishment of FRB, U. S. banks have lived in the tradition to consider it undesirable to depend on FRB borrowing on continuous and long-term basis. On the other hand, FRB too is governed by the principle to extend credit only on short-term basis and this not too frequently. Because of this "tradition against borrowing" and "principle of prudent discounting", it is natural that continued dependence on FRB borrowing has been thought to be undesirable, as it may provoke FRB intervention and result in a loss of credibility.

Furthermore, according to traditional thinking of FRB, their influence to money market interest rates should increase in proportion to the relative size of the borrowed portion in total reserves, even if there is no change in the total reserve amount, once FRB intends to tighten money supply. This is what they call "the re-

6) See Furukawa (1985).

serve position doctrine", referring to the fact that as we discussed in the preceding section I, growth of FRB borrowing tends to invite tightening of FRB surveillance and pressure to reduce balances of the borrowing. For a bank with high dependence of FRB borrowing, the surveillance and pressure for repayment can be taken as factors contributing to increase of the implicit cost of borrowing[7)].

We can easily presume that the same thing will apply in Japan as well, to some extent. Of a particular importance is the fact, as pointed out by those who have studied BOJ behavior such as Kure (1973), Suzuki (1974), Nishikawa (1977), and Yokoyama (1977) that the central bank has full discretion to make loans and recovery of funds, so that banks who depend on BOJ borrowing are under constant pressure as the latter may require repayment at any time. If the increase of BOJ borrowing accompanies that of the pressure, then a borrower should see it as additional increase of the implicit cost.

As to the mechanisms which determine the call rate in Japan, we can classify them into four types according to the degree of elasticity of reserves demand/supply with regard to the call rate:

(a) both of demand and supply of reserves are interest elastic
(b) demand for reserves is interest elastic but supply of reserves is inelastic
(c) demand for reserves is interest inelastic but supply of reserves is elastic
(d) neither demand nor supply of reserves is interest elastic

Of these four types, (d) represents a combination of two conventional views that the demand for reserves is interest inelastic because Japanese banks do not maintain excess reserves, and that the total reserve supply is insensitive to the interest rate since BOJ rations its loans to all banking institutions in the private sector, including so-called city banks as the major borrowers. However, if we assume that both of the demand and supply are insensitive to the call rate, the latter should go up indefinitely as long as BOJ elects to keep the reserve supply below the level of demand, and conversely, if the central bank continues to the supply reserve in excess of the actual demand, the call rate will go down indefinitely until it reaches zero. On the other hand, if the central bank matches the reserve supply to the reserve demand, the demand curve and the supply curve will overlap with each other completely, making it possible to set the call rate at a particular level[8)]. In any event, this case is clearly unrealistic and we can discard it from our consideration.

The case (a) stands for the prevailing view in line with the mechanism by which the Federal Fund Rate is determined as explained in Section 1. It corresponds, therefore, to the equation (7).

The case (b) refers to the model formulated by Kanzaki (1988), Suzuki, Kuroda and Shirakawa (1988) to explain the way the call rate is determined in Japan. This model shows that the call rate is determined by the demand-supply equilibrium

7) See Furukawa (1985) and Kanzaki. (1988)

8) See Iwamura (1991).

of the reserve deposit[9].

Lastly, the case (c) corresponds to a model by Okina (1987, 1991, 1992 and 1993). The model holds that under the Japanese reserve requiremnt system, the demand for reserves tends to be insensitive to the call rate within the reserve "maintenance period", while the supply of reserves is sensitive. As it is, "the interbank rate is determined by the price of supply at the crosspoint of the demand and supply of reserves, that is, at the level corresponding to the marginal price of the reserve supply"[10].

All of these three cases we have considered (see Figure 2) share one point in common that the call rate depends on the demand-supply relationship of reserves, but they are significantly different regarding the assumptions for the interest-elasticity of the reserve demand and supply. As the great difference between the view held by Kanzaki (1988), Suzuki et al. (1988) and Okina (1987) shows, a noteworthy point is that there seems to be the lack of full consensus even among those JOB experts.

III Estimation of Demand and Suppply of Bank Reserves

So far, the number of empirical studies on the behavior of Japanese banks in regard of bank reserves is rather limited. These include Hamada and Iwata (1976), Furukawa (1981), Horiuchi (1881), Kuroda (1988) and some others. Results of their analyses show considerable disagreement between themselves due to the difference of specification of estimated equations, observation period, and so forth. Both Hamada and Iwata (1976) and Furukawa (1981) conclude that the bank's reserve demand is a decreasing function of the call rate, while Horiuchi (1981) and Kuroda (1988) come to an opposite conclusion that the reserve demand is insensitive to fluctuation of the call rate.

Thus, although the conclusions reached by previous analyses on the reserve demand do not agree, they seen to have one problem in common, in that all of them assume that interest elasticity of reserve demand and excess demand are directly related to each other, and that Japanese banks do not carry excess reserves because reserve demand is insensitive to interest rates. Yet, even if we accept the majority view that there is no incentive for Japanese banks to maintain excess reserves, it is still perfectly conceivable that they try to reduce their reserves if and to the extent that the money market rate goes up, as we are now going to see.

Ordinarily, the reserve requirement system requires banking institutions to

9) To say that the overnight interest rate is determined by a demand-supply relationship of reserves is the same as to say that the rate is set by a demand-supply relationship of the high powered money, because by transforming the equation (7), we get:

$$TR(rc)+CU=BR(rc-rb)+BS-DG+FA$$

in which the left side represents the demand for high powered money and the right side represents the supply of it.

10) Okina (1992).

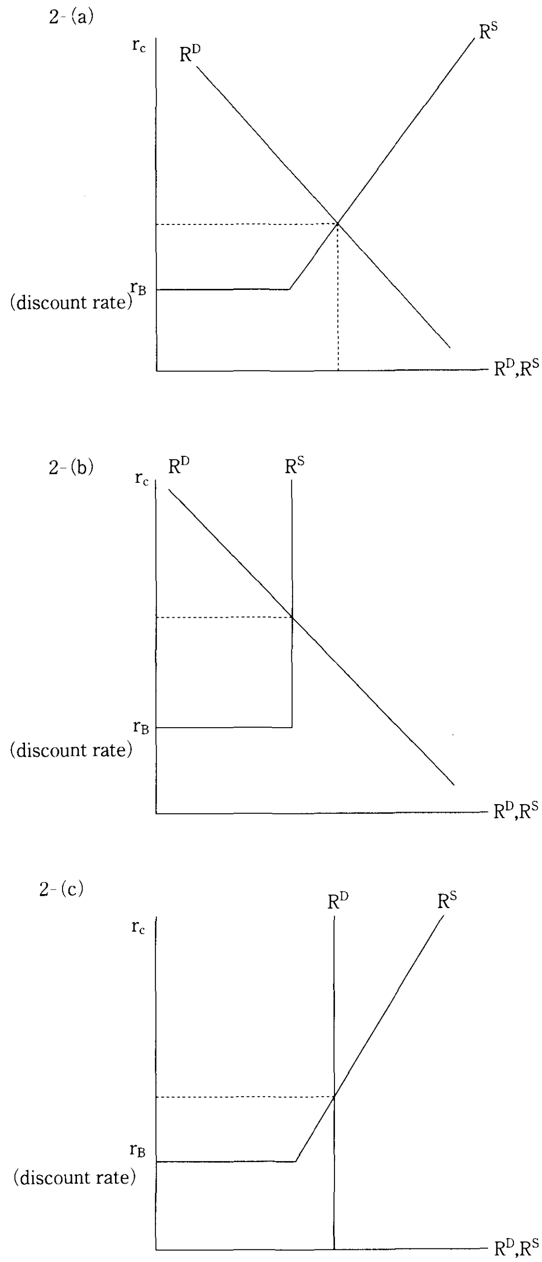

Fig. 2 Determination of the Call Rate in Japan

maintain deposits in certain proportions to their deposits and other liabilities in non-interest bearing accounts at the central bank. In Japan, private banks' required reserves are calculated as the product of the reserve ratio and average deposit outstanding in a callendar month, with the reserve "maintenance period" beginning on the 16th day of that month and ending on 15th day of the following month. Therefore, the Japanese reserve requirement system is a mixture of a "lagged reserve system" and "contemporaneous reserve system". Under this system, a bank must meet the level of total required deposits on the 15th day (the last day of the "month"), but it is free to decide at which pace the reserve is to be set up to the required level during the "maintenance period".

As such, if the bank expects that the call rate is likely to go up during the period ahead, it will accelerate the pace (increase the so-called "reserve progress ratio") in setting up the reserve deposit at BOJ, and conversely, if the market interest rate is likely to come down, the bank will delay the pace in doing so[11]. Thus, it is reasonable to think that the bank, in order to determine the amount of reserve deposit increments on day-to-day basis, should tend to deposit more if the actual call rate is lower than it is likely to be, and do the opposite if the actual call rate is higher in comparison with what it is likely to be[12].

If this premise is correct, then we can definitely say that there is a negative relationship between the balance of reserve deposits and the call rate, even if the banking sector as a whole does not maintain excess reserve at all.

Another issue which arises from past analyses on the reserve demand concerns the concept of the "reserve" itself. Except for the work done by Kuroda (1988), all of the studies made in this area use, as a variable for the purpose of estimating reserves, the amount of the "deposit" appearing on the asset side of the "bank account" of banking institutions such as city banks and regional banks, which is published in the annual economic statistics of the Bank of Japan.

Although the "reserve" mostly consists of current deposits at the Bank of Japan, under the reserve requirement system, it also includes the monetary trust and cross-deposits among banks which, obviously, are not part of the reserve deposits. Moreover, in the current system, the ratio of required reserves applicable to liabilities of banks is different according to types of the liability as well as the scale of deposits. Because of these reasons, it is an extremely complicated task to calculate the amount of the reserve required under the system. Moreover, since BOJ publishes only the balance as of the end of each month, we cannot calculate for the exact amount of required balance corresponding to monthly average of deposits received. As it is, we cannot deny that the past studies lacked somewhat in analytical precision because of the problem inherent in the data used and also because they focused

11) The "reserve progress ratio" is the ratio of reserve deposits accumulated from the first day of a maintenance period to the total cumulative reserve deposits required for that period.

12) Yokoyama (1973), Eguchi (1987), Kanzaki (1988), Okina (1993) recognize the importance of the call rate during the "maintenance period" and of the expected rate in future as a factor to influence the "reserve progress ratio".

their attention to the difference in reserves among different types of banking institutions.

However, inasmuch as the purpose of our present analysis is to study the relationship between reserve deposits and the short-term money market rate for the entire Japanese banking community, it is still quite possible to make use of more suitable data in this study. The data we are going to take up pertain to the figures shown as "balance of reserve deposit" in the annual economic statistics published by the Bank of Japan. This statistical column shows monthly figures of "average balance" and "balance of legal reserve (average)" of the reserve deposits maintained by the banking community with the Bank of Japan. Since these figures do not involve the problems discussed already, we can use them to estimate the reserve demand function in the following equation:

$$lnTR = a_0 + a_1 lnRC + a_2 lnRR \tag{10}$$

TR refers to the "reserve deposit" at BOJ (average balance) and RC to the "call rate" (applicable to secured unconditional borrowings), respectively. Publication of the reserve balance started from January 1978 and for this reason, the estimation is done from January 1978 until December 1992. Reserve deposits are expressed in the unit of 100 million yen (after seasonal adjustment), and the call rate is expressed in percentage. The Maximum Likelihood method is used for the estimation.

The equation (1) in Table 2 indicates results of our estimation of the reserve demand. According to our estimation, the reserve demand arising from Japanese banks under the reserve requirement system depends almost entirely on the level of required reserves. The elasticity of the reserve demand in relation to required reserves is very close to 1, and in contrast to this, the coefficient of the call rate is not in agreement with the anticipated sign nor it is significant.

Table 2 Estimation of the Demand for Reserves

Variables / Equation	Constant Term	LRC	LRR	DUM	$\bar{R}^2$	SE/ ρ
(1)	−0.2857*	0.0007	1.0028***		0.9998	0.0035
	(−1.68)	(0.52)	(607.8)			0.435
(2)	−0.0110	0.0018	1.0010***	−0.0014	0.998	0.0035
	(−0.43)	(0.97)	(386.7)	(−0.90)		0.430

Notes: 1) LRC: call rate (logarithmic)
LRR: required reserves (logarithmic)
DUM: dummy variables, 1 for January 1978 to June 1987 and 0 for July 1987 to December 1992
2) Numbers in parentheses are t-statistics
3) ***: significant at the 1% level.
*: significant at the 10% level.
4) $\bar{R}^2$: R-squared after adjustment for degrees of freedom
SE: standard deviation of residuals
ρ: estimated coefficient of the first-order serial correlation

Next, the equation (2) in Table 2 refers to the result of re-estimation done in view of the fact that the reserve requirement system underwent a major change in July 1987 by introduction of the "progressive excess reserve system" which necessitated use of the structural dummy variable DUM, namely, 1 for January 1978 to June 1978 and 0 for July 1987 to December 1992[13]. Here again, we see that the total reserve demand is fully determined by required reserves. In fact the call rate shows the wrong sign and not significant at all.

Judging from these results of our estimation, we can say that there is no negative relationship between reserve deposits maintained by Japanese banks and the call rate.

Now, let us focus our attention to the BOJ lending which is a major component of the reserve supply in order to see what factors are in play and whether it is sensitive to the call rate. We base our approach on the function of the demand for BOJ loan consistent with the progressive cost structure referred to the equation (9) in the preceding section, and for the purpose of our estimation, two types of equation are used:

$$BR=b_0+b_1(RC-RD)+b_2CU+b_3BR_{t-1} \qquad (11)$$

where $b_1>0$ and $b_2>0$

$$BR=c_0+c_1RC+c_2RD+c_3CU+c_4BR_{t-1} \qquad (12)$$

where $c_1>0$, $c_2<0$ and $c_3>0$

In these equations, BR, BC, CU, and BR_{t-1} represent the call rate, the discount rate, the balance of cash in circulation and the lagged level of borrowing from BOJ, respectively. The difference between (11) and (12) arises because in the former, the total amount of BOJ borrowing shows a positive dependence on the spread between the call rate and the discount rate, whereas in the latter, the BOJ borrowing is assumed to leave a positive dependence on the call rate and a negative dependence on the discount rate.

Both equations make use of the balance of cash in circulation and the lag of a dependent variable in addition to the interest rate. The balance of circulating cash is used as a scale variable because it is one of the market factors contributing to fluctuation in the funds supply or demand in the money market. If others being equal, the increase (or decrease) of cash balances should result in the increase (or decrease) of BOJ borrowings[14]. Also, because it is highly likely that the amount of BOJ borrowing by banks is influenced by the lagged level of BOJ borrowings, the lag of the

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13) The "progressive extra reserve system" is to set a certain number of levels for the balance of deposits received by banks and to apply the higher ratio of required reserves as the deposit balance goes up to higher levels. In the previous system, the ratio of required reserves was dependent on the ranking of banks according to their deposit balance.

14) The problem of choice of a scale variable to account for BOJ borrowings is a difficult one. Furukawa (1985) used the variable which represents "funding position" of city banks. However, from the viewpoint of the exogeneity of a variable, the surplus or shortage of funds, or the balance of currency in circulation, seems to be more appropriate and this is the reason why we used the latter as the scale variable.

dependent variables is added as an explanaory variable[15].

The estimation is done, in the same manner as for the reserve demand, using monthly data for the period from January 1978 to December 1992, except that for the currency, the seasonal adjustment is not made[16]. The Cochrane-Orcutt method is used for the estimation because the independent variable includes the lag of dependent variable.

Table 3 presents the estimation results. As the equations (3) and (5) in the table show, the coefficient of the spread (SP) between the call rate and the discount rate satisfies an expected sign, but they are not significant. In contrast to this, as the equations (4) and (6) tell us, once we assume that the call rate and the discount rate are two variables independent from each other, the estimated coefficient values are not only quite significant, but their signs satisfy expected conditions. This means that the higher call rate causes BOJ borrowings by banks to increase, while lower discount rate causes the decrease of borrowings from BOJ, consistent with the previous assumption.

CU also indicates a high degree of significance, in that if the currency in circulation increases and causes shortage of funds in the money market, banks tend to borrow more from BOJ. This is in agreement with our expectation, too. As to the lag of the dependent variable, it is highly significant in (3) and (4), but in case of (5) and (6), which include both CU and BT_{t-1} as explanatory variables, it becomes completely insignificant, probably due to the influence of time trend inherent in both of CU and BT_{t-1}. For this reason, in equation (7), CU is replaced with CHCU, which is the change in CU, as an explanatory variable for the estimation. The result shows that all independent variables regain high degree of significance and satisfy expected signs about estimated coefficients.

Table 4 is the estimation approximate to the logarithmic linear model. The equations (8) to (11) correspond to the equations (3) to (6) in Table 3. All of estimation results are satisfactory. It is remarkable that the coefficients estimates are significant not only in case the call rate and the discount rate are treated as independent variables, but even if the spread (In RC-In RD) is used as an explanatoy variable.

So far, we used the balance of the circulating currency (CU) or its change (CHCU) as the scale variable and we assumed that it has a significant influence on the amount of BOJ borrowings. But the amount of funds surplus or shortage in the money market may be more appropriate as an explanatory variable instead of the

15) In Goodfriend's model (1983), borrowings done in the preceding period has a negative effect on borrowings in the current period, due to the growth of implicit cost charged by the Central Bank to penalize too frequent FRB borrowings. Yet, as Pearce pointed out (1993), almost all of coefficients of the lagged dependent variable show positive sign according to the results of empirical analyses done in this area.

16) Another estimation was made for a case in which the seasonal adjustment was applied to the variables. The results were close to those obtained without such adjustment, if somewhat inferior compared with unadjusted figures.

Table 3 Estimation of BOJ Borrowings

Equation \ Explanatory Variable	Constant term	SP	RC	RB	CU	CHCU	B_{t-1}	$\bar{R}^2$	SE/ρ
(3)	1187.7	1345.2					0.918***	0.829	11221.2
	(0.62)	(1.29)					(27.78)		−0.302
(4)	10490.0		4897.7***	−7240.6***			0.823***	0.826	10885.9
	(3.01)		(3.23)	(−3.48)			(18.13)		−0.249
(5)	−28308.0***	1809.7			0.223***		0.036	0.444	9554.0
	(−4.71)	(0.77)			(10.01)		(0.49)		0.599
(6)	−5013.3		6008.2***	−10078.0***	0.188***		0.079	0.572	9304.5
	(−0.69)		(2.54)	(−3.19)	(7.98)		(0.94)		0.465
(7)	7677.8***		3868.6***	−5628.7***		0.232***	0.857***	0.835	10002.0
	(2.24)		(2.58)	(−2.73)		(5.44)	(18.88)		−0.169

Notes 1) Variables
SP: interest spread (between the call rate and the discount rate)
RC: call rate
RB: discount rate
CU: balance of cash in circulation
CHCU: change of currency in circulation
B_{t-1}: lag of the variable to be explained
2) Numbers in parentheses are t-statistics.
3) *** indicates significant at the level of 1%
** indicates significant at the level of 5%

Table 4 Estimation of BOJ Borrowings (logarithmic linear model)

Equation \ Explanatory Variable	Constant term	LSP	LRC	LRB	LCU	LB_{t-1}	$\bar{R}^2$	SE/ρ
(8)	1.399***	1.084***				0.835***	0.182	0.395
	(3.53)	(3.17)				(19.31)		−0.174
(9)	1.839***		1.021***	−1.138***		0.811***	0.810	0.394
	(3.44)		(2.94)	(−3.27)		(16.78)		−0.164
(10)	−3.958***	0.953***			0.588***	0.649***	0.778	0.377
	(−2.67)	(2.49)			(3.60)	(8.28)		−0.013
(11)	−3.610***		0.871**	−1.039***	0.621***	0.602***	0.769	0.375
	(−2.35)		(2.21)	(−2.59)	(3.54)	(6.47)		0.016

Notes 1) Variables
LSP: log of the interest spread
LRC: log of the call rate
LRB: log of the discount rate
LCU: log of the balance of cash in circulation
LCH: log of the change of currency in circulation
LB_{t-1}: log of the lag of the variable to be explained
2) Numbers in parentheses are t-statistics.
3) *** indicates significant at the level of 1%
** indicates significant at the level of 5%

currency in circulation or its change. As it is, another estimation is made using the figures given as "surplus or shortage of funds" in the annual economic statistics of the Bank of Japan. Because the balance of BOJ borrowings at a particular time depends not only on the magnitude of the funds shortage in that period but also on the cumulative shortage, we use Almon Lag Distribution method in terms of the variable of "surplus or shortage of funds"[17].

The results of this estimation are given in Table 5. They satisfy expected signs not only for interest variables but also for the "surplus or shortage of funds" and the ajusted R^2 shows the highest values of specifications we have used so far. In particular, we see that the surplus of funds in the market causes a decrease of borrowings from BOJ and the shortage of funds leads to the opposite (SA in this Table, if positive, refers to the surplus of funds, and when negative, means the shortage). As time goes back, the impact of fluctuation of SA decreases. All these agree with our expectations.

Conclusion

It is very immportant to understand the mechanism in which the overnight rate is determined as a part of the whole structure of transmission of monetary policy. This is because change in overnight rate is the starting point of transmission mechanism of monetary policy, in addition to the fact that it is the object of direct manipulation and control by the central bank. As Goodfriend and Whelpley (1986) pointed out, "the overnight rate is the heart of money market rates".

In spite of the fundamental importance of the mechanism for determination of the overnight rate, and of the structure in which money market rates are made, there still is the lack of full consensus regarding how the mechanism works in Japan.

Table 5 Estimation of BOJ Borrowings (ALmon Lag Distribution)

Explanatory Variables / Equation	Constant term	RC	RB	$\sum_{j=0}^{3} \alpha j SA_{t-j}$	B_{t-j}	$\bar{R}^2$	SE/ ρ
(12)	12553***	3114.3**	−5224.6***		0.783***	0.868	9119.9
	(4.17)	(2.34)	(−2.87)		(20.08)		−0.192
	$\sum_{j=0}^{3} \alpha j = -0.456$***			$\alpha_0 = -0.182$,	$\alpha_1 = -0.137$		
	(−8.71)			$\alpha_2 = -0.091$,	$\alpha_3 = -0.046$		

Notes
1) A variable SA is for the shortage/surplus of funds. All other variables are the same as in Table 3.
2) Numbers of parentheses are t-statistics.
3) *** significant at the 1% level
** significant at the 5% level
4) Condition: The degree of polynominal is two and an endpoint constraint is $a_4 = 0$.

17) Selection of the degree of the polynomials and the length of the lag period follows Schmid and Waud (1973).

In this study, we focused our attention to the mechanism with a view that similar to the U. S. overnight rate (Federal Fund rate), the Japanese call rate depends on a demand-supply relationship of bank reserves. Empirical analyses of the reserve demand and supply we have made show that the total demand for reserves arising from the entire banking sector, on the basis of average monthly balance, is not sensitive to fluctuation of the call rate, and that with regard to supply of reserves, there is a significant meaningful positive relationship between loans extended by the Bank of Japan and the call rate. This in fact clearly relates to the case expressed in Figure 2-(c).

Yet, we must hasten to add that we cannot necessarily see any basic difference between the U. S. mechanism setting the overnight rate, which we reviewed in the first section, and the corresponding mechanism in Japan. Or rather, we should say that the mechanism is fundamentally same both in the United States and in Japan. In that the overnight rate is determined by the reserve supply, and that the supply side of reserves is critical to influence the interest rate, our views are not different from traditional thinking in the United States.

The real difference between the two countries relative to setting of the interest rate is that in Japan, demand for reserves arising from the banking sector as a whole is not sensitive to fluctuation of the interest rate, and that the Central Bank, for this reason, has full and unilateral power to set the overnight rate. Yet, in our opinion, we should be careful in jumping at the conclusion too quickly, because whether or not the demand for reserves is sensitive to the interest rate is likely to depend largely on the time period in question.

In the preceding section, we used as an explanatory variable the average monthly balance of the reserve deposit at BOJ, and confirmed that it indicated no response to the call rate. Yet, there is a possibility that the reserve demand shows a definite elasticity against the interest rate depending on the expectation concerning future interest rates, if we look at what is happening on day-to-day basis[18). Moreover, if much longer term such as a quarter or a year is taken, we are quite likely to see that the call rate change does cause fluctuation of loans and deposits, and in consequence, the deposit reserve also changes, demonstrating that the reserve demand is in fact sensitive to the interest rate.

In conclusion, it would be more reasonable for us to stress the commonality between the U. S. and Japanese mechanisms for setting of the overnight rate, rather than to point out the difference.

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18) Recently Uchita (1995) reports that there is a significant negative relation between total reserves and the call rate, using daily data. See also Tanaka (1992).

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