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Makoto Saito
(Hitotsubashi University)
Shigenori Shiratsuka
(Bank of Japan)
Noriyuki Yanagawa
(The University of Tokyo)

Naka 2-1, Kunitachi, Tokyo 186-8603, Japan
Phone: +81-42-580-9076   Fax: +81-42-580-9102
URL: http://www.econ.hit-u.ac.jp/~coe-res/index.htm
E-mail: coe-res@econ.hit-u.ac.jp

Seasonal Demand for Liquid Assets and Yield Curves: Evidence from the Periodic Payment Practice in Japan*†

Makoto Saito‡ Shigenori Shiratsuka§ Noriyuki Yanagawa¶

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Abstract. Taking the periodic payment practice in Japan as a particular calendar liquidity event, this paper empirically examines the effects of liquidity demand on yield curves of money market rates. The sample period used is the decade between the late 1980s and the late 1990s, during which a passive liquidity provision from the Bank of Japan caused serious liquidity events among market participants at the end of each payment month (March, September, or December). According to the estimation results, yield curves were made steeper over daily, weekly, and monthly frequencies at the turn of the payment months not only by expectation effects, but also by strong demand for liquid assets maturing just at each end of these months. Such steepened yield curves were not observed in offshore markets, where participants were not subject to the practice. In addition, the paper discusses the role played by a central bank in removing seasonal patterns in money market rates.

Keywords: liquidity demand, periodic payment, yield curve, calender events, seasonality.

JEL: E43, E44, G11, G32.

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* Correspondence to: Makoto Saito, Faculty of Economics, Hitotsubashi University, 2-1 Naka, Kunitachi, Tokyo, 186-8601, Japan, phone: +81-42-580-8807, fax: +81-42-580-8882, E-mail: makoto@econ.hit-u.ac.jp.

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‡ Faculty of Economics, Hitotsubashi University.

§ Bank of Japan.

¶ Graduate School of Economics, The University of Tokyo.

1. Introduction Taking the periodic payment practice in Japan as a particular liquidity event, this paper empirically examines the effects of demand for liquid assets on short-term yield curves. It provides convincing evidence for the pricing of the convenience of financial instruments that deliver payoffs in a timely manner that link with payment practices. Compared with the situation in the USA, as discussed below, the Japanese periodic payment practice offers a unique natural experiment to empirically test the pricing of such liquidity convenience.

In empirical literature on financial markets, a seasonal pattern in payments or settlements has been well recognized as one possible calendar liquidity event.[1] A payment system standardized at a particular time may constitute a liquidity event by generating strong cash demand at this time and creating spikes in interest rates as a result of tightening markets. Given such a seasonal pattern in payments, economic agents may hold liquid assets as a preparation for tightening cash markets and, consequently, the convenience associated with such liquid assets may be priced in financial markets.

Seasonal patterns in payments and settlements are indeed observable in most developed countries. In the USA, for example, payments between financial and nonfinancial institutions are standardized at the end of each month, particularly at the very end of the calendar year, so that there is rather strong cash demand to complete payments at each month end. Such a seasonal liquidity event may create strong demand for financial instruments that mature at the end of each month. For example, Ogden (1987), Griffiths and Winters (1997), and Park and Reinganum (1986) present empirical evidence of effects of seasonal patterns in payments on money market rates.[2]

Despite the clear presence of payment practices, there are few empirical papers that

[1]Another example of the occurrence of liquidity events during normal periods is the liquidity effect driven by monetary operations, for which empirical evidence has accumulated in the literature. Using interbank market data, for example, Hamilton (1997) finds that the liquidity effect is stronger toward the end of the maintenance period. Hayashi (2001), Uesugi (2002), and others examine the presence of liquidity effects using Japanese interbank market data.

[2]Ogden (1987) finds the corresponding empirical evidence from the Treasury bill market, and Griffiths and Winters (1997) from the term-repo market. By comparing subsequently observed (ex-post) short-term rates with the implied forward rate in the Treasury bill market, Park and Reinganum (1986) find evidence for strong demand for money market instruments with year-end maturity. On the other hand, Musto (1997) and Furfine (2004) interpret year-end patterns in money market rates as not being seasonal payment patterns, but rather window-dressing behavior of financial institutions.

intensively study seasonal patterns in money market rates even in comparison with research on seasonal or calendar patterns of other financial returns such as the January and Monday effects in equity returns. A major reason for this absence may be that, as Miron (1986) and others demonstrate, the Federal Reserve System has, since its founding, actively intervened in money markets in order to absorb liquidity shocks associated with seasonal payment practices, and thereby eliminate seasonal patterns of nominal interest rates. Thus, the seasonal pattern in interest rates as the essential source of liquidity demand is no longer pronounced in U.S. money markets.

Compared with the USA, the periodic payment that prevails as common practice among financial and nonfinancial firms in Japan offers a unique natural experiment to conduct a test of the effects of demand for liquid assets on short-term yield curves for the following reasons. First, the degree of enforcement of this practice is extremely high. Firms subject to this practice must make quarterly payments at the very end of March, September, and December. These firms are quite strict about completing their periodic payments, because failure to do so often jeopardizes the continuation of their business.

Second, the volume of cash demanded at each end of the settlement months is fairly massive. Although the Bank of Japan (hereafter, the BOJ) sets the required reserves at a high level relative to those of other central banks in developed countries, the cash demand exceeds even the required reserves at each end of settlement months. An important note essential to our empirical investigation is that, prior to the last quarter of the year 1997, the BOJ had been reluctant to provide reserves beyond the required level even at each end of the settlement periods. Since money markets were deregulated in the late 1980s, tight credit conditions as a result of this passive policy behavior directly created interest-rate spikes in money markets (including interbank markets) at the settlement month ends. Since the fourth quarter of 1997, when the Japanese financial markets suffered severely from liquidity crises, the BOJ has intervened heavily in money markets to remove interest-rate spikes at each turn of the settlement months.

Given such a passive liquidity provision on the side of the BOJ as well as the above strict enforcement of the payment practice, private institutions, both nonfinancial and financial, were forced to prepare for the periodic payment by carrying large amounts of liquid assets, partly because of tightening credit conditions toward each end of the payment months and partly because of their consideration of their counterparties' credit risks in settlements. Such strong demand for liquid assets is expected to have substantial impacts on yield curves in money markets.

One distinctive feature of this kind of liquidity demand is that it is a payment practice that draws the distinction between liquid and illiquid assets in terms of the timing of cash delivery. In particular, an instrument that matures at that particular point is preferred to one that matures beyond it, because the former instrument delivers certain payoffs at the time of the liquidity event; consequently, the yield of the former instrument is lower than that of the latter. In this case, a steeper yield curve is motivated, not only by expectations of spikes in money market rates at this time, but also by stronger demand for instruments maturing at the time of liquidity events. What will be emphasized in our empirical investigation is, not only the interest-rate spikes themselves, but also the strong demand for liquid assets as a preparation for the tight cash conditions represented by spikes.

More specifically, we will compare subsequently observed (ex-post) short-term rates with the implied forward rate in money markets, and thereby separate the effect of demand for liquid assets from the effect of expectations about interest-rate spikes at the end of the year. Then, we will examine whether the yield on money market instruments with year-end maturity is significantly lower as a result of strong demand for such instruments. For this purpose, we will justify an empirical method used by Park and Reinganum (1986) within a theoretical framework of Holmström and Tirole (2001), and apply it to Japanese money market data.

In addition, we will discuss a possible role played by a central bank in removing seasonal patterns in interest rates. This type of policy consideration is even more important given the historical fact that, in capitalist countries, seasonal liquidity events often led to macroeconomic liquidity crises during the nineteenth century, as Miron (1986) and others demonstrate. Although policy success in removing seasonal patterns in interest rates in developed countries during the twentieth century tends to obscure this potential role of a central bank, the recent Japanese experience sheds light on the importance of this policy issue.

This paper is organized as follows. Section 2 discusses how the periodic payment practice is followed in Japan, and derives a simple empirical implication from Holmström and Tirole (2001). Section 3 presents estimation results. Section 4 provides a conclusion.

2. Periodic payment practice and its implication for yield curves

2.1. **Periodic payment practice** In Japan, both nonfinancial and financial institutions are subject to the periodic payment practice at the end of each month. Such payment flows are particularly concentrated at the end of March (corresponding to the end of the fiscal year), September (the month when private firms announce interim accounts), and December (the end of the calendar year). At the very end of these payment months, nonfinancial and financial institutions are involved in extremely intensive payments between debtors and creditors. They are quite strict about completion of the periodic payment, because failure to settle will certainly damage their credit and often jeopardize the continuation of their business.

Reflecting the above periodic payment practice, the daily payment flows of the major fund clearing systems, consisting of the Bill and Check Clearing System and the Domestic Fund Transfer System (the *Zengin* System), through the BOJ reserve accounts[3] have clear spikes at the end of each month, in particular March and September (see Figure 1). More specifically, the daily payment flow is more than four times as large as the required BOJ reserves (around four trillion yen) at each end of these two months. Figure 1 conclusively demonstrates that payments through the two fund clearing systems are heavily concentrated at the end of March and September.[4]

At the end of December, it is not payments through the two fund clearing systems but cash payments that are traditionally dominant. Accordingly, the outstanding amount of

[3]Financial institutions, in particular city and regional banks, use the Bill and Check Clearing System to clear bills and checks that are drawn for payment, mainly by corporations. In Japan, personal checks are not used widely. On the other hand, the Domestic Fund Transfer System electronically transfers funds between banks according to requests of bank customers, including individuals and corporations. The two fund clearing systems settle net positions through the BOJ reserve accounts held by financial institutions.

[4]Another reason why money markets are seriously tight in March (the end of the fiscal year) is that regional banks, usually major creditors in markets, are reluctant to lend loans because they attempt to reduce the risk capital required by the Bank for International Settlements (BIS) regulation as much as possible. In this sense, the window-dressing behavior of regional banks is partly responsible for tight cash markets at March end.

cash in circulation increases dramatically in December, reaching a peak at the very end of the calendar year.

Because of the extremely large daily payment flows at each end of the payment months, the reserve demand tends to exceed the level of the required BOJ reserves. The BOJ, however, had been reluctant to provide the reserves beyond the required level prior to the last quarter of 1997. As shown in Figure 2, the ratio of the outstanding reserves relative to the required reserves had been stable at around one before the last quarter of 1997. Among the reasons for this passive liquidity provision, is that the BOJ wanted to respect market outcomes without heavy intervention, which is a basic principle of the market deregulation policy started in the mid 1980s.

Such a passive liquidity provision against extremely strong demand requires large adjustments in spot interest rates in deregulated money markets, particularly the call market (the interbank market); in Japan, the uncollateralized call market was deregulated completely in 1988. As Figure 3 shows, the overnight uncollateralized call rate frequently experienced sharp spikes at the end of these payment months for the corresponding period. However, the collateralized call market rarely experienced such spikes; even the uncollateralized call market, which was introduced in 1985, had not generated spikes associated with the periodic payment practice before the money market was deregulated completely in 1988. As the preceding discussion suggests, as a result of the passive liquidity provision of the BOJ, the periodic payment practice indeed constituted serious liquidity events for market participants at the very end of these payment months.

Because of legal and social enforcement, such an economy-wide liquidity shock generated strong liquidity demand as a preparation for punctual payments. That is, firms voluntarily accumulated enough liquid assets in advance of the periodic payment by rolling over funds in money markets, partly because of tight credit conditions during the payment month, and partly because of their consideration of counterparties' credit risks in settlements. Reflecting this strict enforcement associated with the periodic payment practice, firms' financial arrangements with commercial banks often financed not only projects, but also operational funds or cash, for periodic payments. In fact, even with their borrowing ties to their main banks, Japanese business firms often carried extra cash in the form of deposits or money market instruments as a buffer against liquidity shocks.

One theoretical justification for the periodic payment practice is to economize liquidity uses as a whole by concentrating payments at a particular time. However, when such payment standardization results in economy-wide liquidity events, then market participants must bear the opportunity costs of holding liquid, but less profitable, assets in advance. In this paper, we pay attention to the latter aspect (the cost) of the periodic payment practice, and explore the role of a central bank in reducing such a cost.

2.2. Possible implications for yield curves

A simple version of Holmström and Tirole This section briefly reviews a simple version of a liquidity-based asset-pricing model presented by Holmström and Tirole [2001], thereby clarifying possible implications for the effects of the above type of calender liquidity events on yield curves in money markets.

There are three periods, $t = 0$, 1, and 2. Consumers are risk-neutral with zero time preference. There are N identical entrepreneurs who are again risk- neutral with zero time preference. Each entrepreneur is endowed with one project, but without any initial fund.

Each project requires investment I as a setup cost at date 0, and y as an interim input at date 1, and the project generates random income x at date 1, and a deterministic income $by - \frac{y^2}{2}$ at date 2. Random income x represents aggregate shocks, and is the same for all entrepreneurs. x is continuously distributed with density $g(x)$ on $[0, \infty)$ with $Ex > I$. The date-1 reinvestment opportunity may be interpreted as an economy-wide liquidity event. In our context, under a liquidity event or lower x, a firm would lose benefits from continuing operations afterwards.

There are several constraints for entrepreneurs and consumers. First, entrepreneurs cannot finance interim inputs at date 1. Such a borrowing constraint may be justified by the assumption that date-2 revenue $(by - \frac{y^2}{2})$ is a private and unverifiable benefit. Entrepreneurs may demand liquid assets at date 0, such that they may not be forced to give up reinvestment on interim inputs at date 1.

Second, the government, as the only borrower, issues bonds at date 0, while consumers are not allowed to make any short position including derivative transactions. The difference in the borrowing ability between the government and the household sector is due to either the information advantage derived from the tax authority or the government's ability to commit to long-run contracts. The government issues two types of discount bonds: one is issued at a price q and repaid by one unit of goods at date 1, and the other is issued at a price Q and repaid by one unit at date 2.

Reflecting that the long-term bond suffers from interest-rate risks at date 1, the price at date 1 (θ) is assumed to be continuously distributed with density $h(\theta)$ on $[0, \infty)$ with $E\theta = 1$. A fixed supply of the short-term (long-term) bonds amounts to l ($\overline{L}$). Given the inability of consumers to make any short position, there may emerge $q > 1$ and $Q > 1$ in equilibrium.

Entrepreneur i invests I as setup costs, and holds l_i (L_i) units of short-term (long-term) discount bonds by borrowing $I + ql_i + QL_i$ at date 0, while he/she can reinvest $y(x)$ on an interim input up to $x + l_i + \theta L_i$, depending on the realization of x at date 1. That is, the reinvestment policy must satisfy

$$y(x) \leq x + l_i + \theta L_i \tag{1}$$

for every realization of x.

With respect to contracts with entrepreneur i, consumers lend $I + ql_i + QL_i$ at date 0, and receive $x + l_i + \theta L_i - y(x)$ at date 1. If consumers lend competitively to entrepreneurs, then they expect a zero rate of return on the above investment, or

$$E_0 \left[x - I - y(x) - (q-1)l_i - (Q-1)L_i\right] = 0, \tag{2}$$

where E_0 is the date-0 expectation operator.

Then, the optimal contract between entrepreneur i and consumers maximizes the surplus generated for entrepreneur i at date 2, or

$$E_0 \left[by(x) - \frac{y(x)^2}{2}\right], \tag{3}$$

with respect to $\{y(x), l_i, L_i\}$ subject to equations (1) and (2). The clearing conditions of the government bond markets lead to $l_i \times N = \bar{l}$ and $L_i \times N = \overline{L}$, given that entrepreneurs are identical.

Given the above setup, Holmström and Tirole derive the following pricing kernel for the date-1 payoff $z(\theta)$:

$$z(\theta) = \int_0^{y^* - \bar{l}/N - \theta\overline{L}/N} \left[\frac{1}{\mu} (b - y(x)) - 1 \right] g(x)dx + 1,$$

where μ denotes the Lagrange multiplier associated with constraint (2), and y^* $(= b - \mu)$ is the solution to the maximization of equation (3) without any constraint. It is possible to prove that $z(\theta)$ is decreasing in θ, and that the covariance between θ and $z(\theta)$ is negative. The intuition behind these properties is that an increase in θ leads to a relaxation of borrowing constraint (1) and, consequently, to a decline in the marginal private benefit.

The short-term and long-term bonds are then priced according to the above pricing kernel as follows: $q = E_0 [z(\theta) \times 1]$ and $Q = E_0 [z(\theta) \times \theta]$. Given that $E\theta = 1$ and $Cov(\theta, z(\theta)) < 0$, it is easy to demonstrate that

$$q > Q \geq 1.$$

In other words, short-term rates are lower than long-term rates, and the yield curve is now upward sloping. The reason why long-term bonds are priced lower is that the embodied interest-rate risk reduces the benefit of long-term bonds as a device to finance the liquidity event.[5] Q is bounded at one because consumers purchase long-term bonds as soon as $Q < 1$.

It is possible to reinterpret the above implication for the term structure as follows. In this setup, the short-term bond matures when the liquidity event is realized, whereas the long-term bond matures after its realization. Therefore, in the context of the expectations hypothesis, the current yield spread $(q - Q)$ should correctly reflect the expectation of the future spot rate that will start when the liquidity event is realized $(E(1 - \theta))$. That is, $q - Q = E(1 - \theta)$ holds exactly under the expectations hypothesis. On the other hand, the

[5] More rigorously, once there is a possibility that liquidity constraints are binding at date 1, then aversion to interest-rate risks, driven by concavity of date-2 private benefit $(by - \frac{y^2}{2})$, is responsible for the liquidity premium $q - Q$.

above model with liquidity demand demonstrates that the forecast based on the current yield spread tends to overestimate the future spot rate ($q - Q > E(1 - \theta)$).

Relaxing the assumption of zero time preference and three periods, we can still define the above implication as the deviation from the expectations hypothesis. Suppose that the economy starts at date t, and that the liquidity event takes place at date $t + i$. Then, $r_{t,i}$ ($r_{t,j}$) denotes the i-period (j-period) spot rate at date t. When $i < j$, then the i-period (j-period) bond corresponds to the short-term (long-term) bond in the context described above.

The forecast of the $(j - i)$ period spot rate prevailing at date $t + i$ ($r_{t+i,j-i}$) based on the expectations hypothesis corresponds to the i-period-ahead $(j - i)$-period forward rate, or $f_{t,i,j-i} = \frac{1}{j-i}(j \times r_{t,j} - i \times r_{t,i})$. If the date-$(t + i)$ liquidity event has a significant effect on the term structure, then the forward rate tends to overestimate the future spot rate, or

$$f_{t,i,j-i} = \frac{1}{j-i}(j \times r_{t,j} - i \times r_{t,i}) > E_t r_{t+i,j-i} \tag{4}$$

is obtained.[6] We will empirically examine the above inequality (4) in the next section.

Empirical specifications in the related literature This subsection compares the empirical specification characterized by equation (4) with those in the existing literature, in particular empirical studies of calendar effects in money markets.

One advantage of using a calendar-date-associated event as a liquidity event is that it is easy to differentiate liquid assets from illiquid ones according to calendar dates of maturity. In our context, the periodic payment practice itself draws the distinction between liquid and illiquid assets in terms of the timing of cash delivery. Given extremely strong cash demand at a liquidity event, a financial instrument that matures at the time of a liquidity event is preferred to an instrument that matures beyond it, because the former is sure to deliver cash at the time of a liquidity event without any exposure to interest-rate risks. In particular, when the condition of cash markets is extremely tight at a liquidity event, the latter instrument is seriously subject to interest-rate risks. Consequently, the latter

[6]Following existing empirical research, our specification ignores the effect of Jensen's inequality, which is often assumed to be quite small and accordingly negligible.

instrument is discounted more than the former, and the term structure of interest rates has a jump at the turn of the time of a liquidity event. Ogden (1987), and Griffiths and Winters (1997) exploit this implication using U.S. money market data.

Their method, however, may not explicitly differentiate the effect of liquidity demand on yield curves from the effect of expectations of future interest-rate spikes. A liquidity event itself may contribute to the generation of spikes in overnight rates at liquidity events. If it is the case, a jump in yield curves at the turn of a liquidity event may just reflect such a spike through an expectation channel. Therefore, it is critical to carefully examine whether such a jump in yield curves can be explained, not only by expectations about interest rates, but also by liquidity demand as an additional and essential factor.

In this regard, an empirical method proposed by Park and Reinganum (1986) is quite useful and justifiable within the framework of Holmström and Tirole (2001). They carefully compare the forward rate implied by a steepened yield curve with the subsequently observed (ex-post) short-term rate for the corresponding period, and examine the degree of systematic overestimation of the forward rate at the turn of a liquidity event. Their method allows one to control for the effect of expectations about tight markets at the time of a liquidity event, and thereby identifies a pure effect of liquidity demand on the slope of a yield curve.

Another potential advantage of the above empirical method is to clearly differentiate the effect of calendar liquidity events from other hypotheses associated with calendar effects such as a window-dressing hypothesis or a tax-loss selling hypothesis.[7] The latter two hypotheses do not carry any specific implications for yield curves or (implied) forward rates.

3. Empirical Specification and Estimation

3.1. **Data** Our estimation procedure uses money market rates available from the following three markets: the call market, the GENSAKI market, and the euro yen market (the

[7] There are several papers that interpret calendar effects of money market rates along a window-dressing hypothesis. Furfine (2004) attributes year-end premiums on overnight interbank rates to window-dressing behavior among financial institutions, and Musto (1997) interprets year-end price shifts in commercial paper rates along a window-dressing hypothesis.

Japan offshore market, or JOM). Each data set has strong and weak points.

The call market is an interbank market, and its rate only reflects liquidity needs from financial institutions. However, because very short-term contracts such as overnight and one-week contracts make up a large part of this interbank market, we can focus sharply on the very end of the payment months as shown in the next subsection.

The GENSAKI market is an open money market where not only financial institutions, but also nonfinancial firms, trade repurchase contracts. This market had been the most representative open money market until the repo market was introduced in 1996. Thus, it is likely to be subject to domestic conditions such as the periodical payment practice. Unlike in the call market, however, the shortest term is one month in the GENSAKI market.

The euro yen market is an interbank market as is the call market, but it is only used by highly rated banks. The market enables Japanese banks to obtain finance from foreign institutions; however, Japanese institutions are unlikely to finance liquidity needs caused by domestic payment practices in the offshore market, partly because of taxation and transaction costs. In addition, distortion in the term structure, if any, is likely to be arbitrated immediately by creditworthy banks (including foreign institutions) participating in this market. Accordingly, we regard the offshore market as a controlled environment where the market rate is free from the liquidity demand motivated by the periodic payment practice.

The frequency of the above data sets is daily, and the sample period is between November 1988 and November 1997. We have chosen this sample period for two reasons. First, the domestic money markets were strictly regulated until the mid 1980s; before the mid 1980s, market rates were unlikely to properly reflect the demand-supply condition. The call market was deregulated in November 1988 and, since then, its rate has been determined on a market quote basis.

Second, as discussed in the introduction, the BOJ has intervened heavily in domestic money markets since late November 1997 in response to the liquidity crises.[8] More specifically, as Saito and Shiratsuka (2001) demonstrate, the BOJ initially attempted to flatten

[8]Yamaichi Shoken, one of the leading securities companies in Japan, went bankrupt on November 22, 1997.

the yield curve through complicated market operations,[9] and later implemented a zero-interest-rate policy. Accordingly, spikes in interest rates at the time of payment have been almost completely removed by such active monetary policies, despite the autonomous market mechanism motivated by the periodic payments. Thus, the periodic payment practice no longer constituted a liquidity event at each end of these payment months.

3.2. **Specification and estimation results: the case of overnight rates** The first estimation concerns the forecasting error of the so-called MATSU-SHO rate observed in the call market, the rate that starts on the final day (MATSU in Japanese) of the payment month, and ends on the first day (SHO) of the next month. Since one-day-ahead one-day-forward contracts (tomorrow next) are traded in the call market, the forecasting error can be defined as $f_{t,1,1} - r_{t+1,1}$ at time t, where $f_{t,1,1}$ is the tomorrow-next rate, and $r_{t+1,1}$ is the corresponding ex-post overnight rate.[10] [11] Unlike other estimation procedures, the sample period starts in May 1994 because the above forward contract has been traded actively since the mid 1990s.

Figure 4 plots the forecasting errors for overnight call rates as defined above. This figure clearly demonstrates that the forecasting errors frequently jump up at the very end of the payment months. This implies that the spikes of the overnight call rate at the end of the payment months are unlikely to be explained just by the expectations hypothesis of interest rates.

The forecasting error defined above is regressed on three types of timing dummy variables. The first dummy, denoted by **DMSD**, takes a value of one at the time of forecasting for the final day of the payment month, or one day before the end of either March, September, or December, otherwise zero. The second, denoted by **DOTM**, takes a value of one, one day before the end of the nonpayment month (January, February, April, May, June,

[9]In particular, the BOJ implemented the so-called dual operation by both purchases in longer-term money markets and sales in shorter-term money markets in 1997 and 1998.

[10]In related empirical research, Hayashi (2001) examines the systematic error between the half-a-day-ahead morning forward rate and the corresponding ex-post afternoon rate. In the context of his research, the massive clearance payment at 1:00 p.m. may be considered as a system-wide liquidity event.

[11]Because banks with low ability to finance in the spot call market often make the tomorrow-next contract, the forward rate tends to be larger than the corresponding spot rate by the order of credit risk even at ordinary times. What we test in this empirical exercise is not such a credit premium observed throughout time, but a liquidity premium generated at the time of periodic payment practices.

July, August, October, or November), otherwise zero. The third, denoted by **DRR**, takes a value of one, one day before the final day of the reserve maintenance period each month, otherwise zero.

Money markets may be tighter in one payment month than in another, because the market tightness is caused by factors other than the periodic payment. With due consideration for such cases, the following explanatory variables are also included to represent the degree of tightness in the money market. When money markets are rather tight, one-week call rates tend to increase toward the end of the month. For each one-day-before-month-end observation (an observation with either **DMSD** = 1 or **DOTM** =1), **C1WMSD** (**C1WOTM**) denotes a change in one-week call rates from "four business days" before the final day of the three payment months (the nine nonpayment months) to "two day" before; when market tightness is expected for the final day of each month, one-week rates tend to jump up immediately after the end of the one-week contract that covers the final day.

Similarly, for observations with **DRR** =1, **C1WR** denotes a change in one-week call rates from "four business days" before the final day of the reserve maintenance period to "two day" before, implying tightness in the call market toward the final reserve maintenance day.

Finally, **DFS3** denotes the dummy variable that takes a value of one when there is a fund shortage of more than three trillion yen in the cash market because of strong demand from the fiscal and private sectors on the following day. Otherwise, its value is zero. The market participants can anticipate such a large-scale cash shortage quite accurately at least one day before; therefore, this dummy variable can be included as an explanatory variable.

In addition, we add a set of dummy variables that indicate the change in the official discount rate, thereby controlling for the impact of the unexpected policy change on the forecasting error; that is, these dummy variables take one in the presence of changes in the official discount rate, otherwise zero. Table 1 reports the estimation results, where the standard error is adjusted for heteroskedasticity and autocorrelation with one-day lags based on Newey and West (1987).

As the estimated coefficient on **DMSD** clearly demonstrates, the tomorrow-next rate substantially overestimates the corresponding overnight rate just before the final day of the three payment months. According to the estimated coefficient on **C1WMSD**, available from the estimation with the dummy variables of the policy change, overestimation is even more remarkable when the call market is fairly tight.

As the estimated coefficient on **C1WOTM** suggests, even for the nonpayment month-ends, overestimation, although weaker, arises when money markets are tight. Additional, though less substantial, overestimations take place just before the final day of the reserve maintenance periods and on the day when a substantial shortage is expected in the cash market. These estimation results do not change substantially even if the sample period starts in September 1995, when the policy instrument was effectively changed from the official discount rate to the overnight call rate.[12]

3.3. **Specification and estimation results: the case of weekly rates** The second estimation procedure uses the one-week call rate ($r_{t,5}$) as a forecaster, and the rolling rates on the overnight call market ($\{r_{t+i,1}\}_{i=0}^{4}$) as ex-post rates. The forecasting error is thus defined as $r_{t,5} - \frac{1}{5}\sum_{i=0}^{4} r_{t+i,1}$ at time t. The defined forecasting error is regressed on the dummy variables of the last four days before the end of each month (**DMX,** where **M** is from January through December and **X** is from four to one) as well as those of the last four days before the end of the reserve maintenance periods (**DRX**, **X** is from four to one). In addition, as in the previous procedure, a set of explanatory variables includes the variables of changes in the official discount rates. Table 2 reports estimation results, where the standard error is adjusted for heteroskedasticity and autocorrelation with one-week lags. Figure 5 plots the estimated coefficients on the four month-end dummy variables of each month (**DM4**, **DM3**, **DM2**, and **DM1**) for the case in which policy changes are considered.

As Figure 5 clearly demonstrates, the estimated coefficients on the four **DMX**s of each month indicate that overestimation takes place as soon as the end of the one-week contract covers the MATSU-SHO rate in the payment months, March, September, and December. Overestimation is most serious in the March payment. During the last four days in each

[12]More specifically, the BOJ first changed the policy instrument from the official discount to the overnight call rate in March 1995. The market participants, however, did not recognize the change in policy instruments very well. When the BOJ announced the call rate as target again in September 1995, they started to pay serious attention to the change.

payment month, on the other hand, overestimation is a little weaker on the day immediately before the end of the month as opposed to the preceding three days. The latter finding suggests that the liquidity premium decreases as uncertainty about the periodic payment is resolved to a great extent just before the final day of the payment months. The above findings are unchanged, even if the sample period is split in 1995.

3.4. **Specification and estimation results: the case of monthly GENSAKI rates**

Three types of implied forward rates, one-month-ahead one-month-forward rates ($f_{t,1,1}$), one-month-ahead two-month-forward rates ($f_{t,1,2}$), and two-month-ahead one-month-forward rates ($f_{t,2,1}$), can be constructed from one-month, two-month, and three-month rates available from the GENSAKI market. As a result, the forecasting error can be defined as the difference between the implied forward rate and the corresponding ex-post rate, or $f_{t,i,j} - r_{t+i,j}$.

In order to examine the presence of systematic forecasting errors, we regress the above error on the timing dummies that are constructed as follows. First, each month is divided into four periods, (i) the period of the first week, (ii) the period after the first week until the last day of the reserve maintenance period, (iii) the period after the last day of the reserve maintenance period before the last week, and (iv) the period of the last week. Second, a dummy variable $m_{t,i,j}$ is constructed for the jth period of month i at time t. The empirical specification is thus defined as follows:

$$f_{t,i,j} - r_{t+i,j} = \sum_{ii=1}^{12} \sum_{jj=1}^{4} \beta_{ii,jj} m_{t,ii,jj}$$

The above specification excludes constant terms to avoid linear dependence.

If the implied forward rate overestimates the future spot rate in a particular timing, then the corresponding coefficient on a monthly dummy $\beta_{i,j}$ is significantly large. As in the previous procedures, we also report the case where explanatory variables include the dummy variables of changes in the official discount rates.

More specifically, considering that payments are concentrated during the last week of each payment month i, $\{\beta_{i-1,j}\}_{j=1,2,3,4}$, in particular $\beta_{i-1,4}$, should capture the effect of overestimation and, therefore, be large relative to other adjoining coefficients in the case of one-month-ahead rates. $\{\beta_{i-2,j}\}_{j=1,2,3,4}$ should be large for payment month i in the case of two-month-ahead rates. Only the estimation results of the case of one-month-ahead one-month rates are reported in Table 3, where the standard error is adjusted for heteroskedasticity and serial correlation with lags of one month. Those of the cases of both one-month-ahead two-month rates and two-month-ahead one-month rates are available upon request.

The estimated parameters are not necessarily consistent with predictions in cases without any policy dummy variables. However, once the policy dummies are included as explanatory variables (as surprises about monetary operations are controlled), then the estimated coefficients on $m_{t,i,j}$ yield a pattern consistent with the theoretical prediction in the case of one-month-ahead one-month rates (the third column of Table 3).

As shown in Figure 6, the coefficients associated with February, August, and November (one month before each payment month) are large relative to those associated with adjoining months, thereby implying that assets with maturities at a payment month are priced more highly than assets with maturities beyond it. The adjoining peaks and bottoms depicted in Figure 6 are statistically different at the 5% level of significance, except for between the January bottom and the February peak. Although not reported in this paper, the case of one-month-ahead two-month rates follows the same pattern as above, whereas the case of two-month-ahead one-month rates does not generate any consistent pattern, even after controlling for unexpected policy changes.

3.5. **Specification and estimation results: the case of monthly euro yen rates**

We apply the same empirical framework as in the previous subsection to the monthly rate available from the euro yen market or, more specifically, the euro yen TIBOR (Tokyo interbank offered rates). Only the estimation results of the case of one-month-ahead one-month rates are reported in Table 4, where the standard error is adjusted for heteroskedasticity and serial correlation with lags of one month. Those of the cases of both one-month-ahead two-month rates and two-month-ahead one-month rates are available upon request.

According to Table 4, however, the evidence for this prediction is not as strong as in the previous result of GENSAKI rates. In Table 4, $\{\beta_{8,j}\}_{j=1,2,4}$ and $\{\beta_{11,j}\}_{j=2,3}$ are indeed significantly positive in cases using the policy dummy variables, but $\{\beta_{2,j}\}_{j=1,2,3,4}$ tends to be rather small, which is contrary to the prediction. The estimation results of the other two cases, not reported in this paper, basically follow the pattern demonstrated in Table 4.

As discussed before, however, the above finding or the absence of strong liquidity impact is fairly reasonable in that participating financial institutions, often highly rated, are unlikely to finance liquidity demand because of the domestic payment practice in the euro market. In addition, any distortion in the term structure is likely to be arbitrated by creditworthy banks participating in the offshore market; consequently, it would be difficult to observe distortion motivated by payment practices in this market. On the other hand, as shown in the previous subsection, the liquidity impact is strong in the GENSAKI market. It thus follows from the comparison of these two markets that, in the open domestic market, where financial institutions as well as nonfinancial institutions take part, the term structure of interest rates is substantially distorted by liquidity demand due to domestic payment practices.

4. Conclusion This paper has presented clear evidence of the effect of liquidity demand motivated by the Japanese periodic payment practice on the yield curves in money markets by exploiting empirical implications available from theoretical models including Holmström and Tirole (2001). In terms of overnight and one-week forecasting in the call market, we find that assets with maturities at the end of the payment months, March, September, and December, are indeed more highly priced than assets with maturities beyond the last day of these months. Such findings are quite robust with respect to alternative specifications and different sample periods. With regard to the one-month-ahead forecasting in the GENSAKI market (the repurchase market), estimation results also present evidence of the liquidity impact of the periodic payment on the term structure of interest rates. In contrast, there is no clear evidence in the euro yen market (the offshore market), where the money rate is expected to be free from liquidity demand due to the domestic payment practice.

As suggested from our estimation results, the periodic payment practice indeed constituted a serious liquidity event for market participants, at least before the last quarter of the year 1997, because the BOJ had been unwilling to supply liquidity beyond the required reserves level. Since then, however, the BOJ have intervened heavily in money markets to eliminate interest-rate spikes at the time of the periodic payment practice by providing reserves beyond the required level (see Figure 2). The dramatic change in its monetary operations was motivated by a deep concern that a seasonal liquidity event might trigger an economy-wide liquidity crisis under fragile conditions of the financial sector, which is the same concern borne by central bankers of the early twentieth century.[13]

More specifically, the reserves supplied by the BOJ were one and a half times as large as the required level at each end of the payment months in late 1997 and 1998. In February 1999, the BOJ introduced the zero-interest-rate policy; it decided to commit itself to zero interest rates (overnight rates) until deflationary pressure was wiped out completely. The BOJ temporarily removed its zero-interest-rate policy in August 2000. The BOJ, however, introduced the quantitative easing policy by which the targeted level of the BOJ reserves was set beyond the required level (around five trillion yen) in March 2001. The targeted level reached thirty trillion yen as of the end of the year 2004, about five times as large as the required level (see Figure 2). These extremely aggressive liquidity provisions jointly contributed to the complete elimination of interest-rate spikes at the time of the periodic payment months.

Thus, one legitimate policy question is whether these aggressive monetary policies could indeed help to reduce the opportunity costs incurred in holding liquid assets in advance in preparation for the periodic payment, or to remove the steepness of short-term yield curves at the turn of the periodic payment months.

As examined in detail by Saito and Shiratsuka (2001), on the one hand, during the period of financial crises between late 1997 and early 1999, the forecasting errors of implied forward rates increased significantly and remained high (not only in the payment months, but also in the other months) despite the spikes of overnight call rates being eliminated by the BOJ's aggressive policy response. Reflecting extremely strong demand for liquid assets throughout that period, steep yield curves were observed, not only in domestic money markets, but also in offshore transactions associated with Japanese commercial banks.

On the other hand, even steep yield curves almost disappeared in money markets under

[13]Fukuda and Shao (1992) find that seasonal patterns in Japanese money market rates disappeared even before World War I, and attribute this disappearance to the founding of the Bank of Japan in 1885.

both the zero-interest-rate policy and the quantitative easing policy. There is circumstantial evidence that such heavy intervention of the BOJ was required urgently to remove steep yield curves in money markets. That is, after the BOJ lifted the zero-interest-rate policy in August 2000 and before it introduced the quantitative easing policy in March 2001, short-term yield curves became rather steep at the turn of the two settlement months, September and December 2000. In this respect, a central bank can indeed play a pivotal role in absorbing seasonal liquidity shocks and thereby in dampening liquidity demand to a large extent. Market participants may benefit from such a timely liquidity provision from a central bank, which minimizes the opportunity cost associated with precautionary holdings of liquid assets. The Japanese experience indeed confirms the conventional wisdom that a central bank should eliminate the movement of interest rates caused by seasonal liquidity events.

However, there remains one important and subtle question as to the degree of the BOJ intervention in money markets. A temporary reserves provision beyond the required level at the time of the periodic payment practice up to the early 2001 may have been justifiable as an effective instrument to absorb seasonal liquidity shocks. In addition, through the Lombard-type lending facility (introduced in February 2001)[14], the BOJ could promptly provide low-cost liquidity for last-minute borrowers at the time of liquidity events. On the other hand, a prolonged provision of excess reserves from the early 2001 may call for a careful investigation, particularly in terms of the size of excess reserves. The BOJ experience itself, with its wild swing from a rather passive liquidity provision to an extremely aggressive one, would suggest that it would be difficult to determine an appropriate level of a central bank intervention in regard to the elimination of seasonal liquidity shocks and the removal of steep yield curves.

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Table 1: Biases in Forecasting Errors: Forecasting One-Day-Ahead Overnight Rates Based on the Tomorrow-Next Transaction

	From May 16, 1994 to Nov. 21, 1997								From Sep. 12, 1995 to Nov. 21, 1997			
Constant	1.249	(0.116 ***)	1.168	(0.098 ***)	1.249	(0.116 ***)	1.168	(0.098 ***)	0.996	(0.102 ***)	0.996	(0.102 ***)
DMSD	25.676	(12.464 **)	7.488	(3.814 **)	24.991	(12.895 **)	1.589	(0.751 **)	8.004	(4.343 **)	1.472	(0.854 **)
DOTM	0.110	(0.324)	0.191	(0.318)	-0.035	(0.340)	0.045	(0.334)	0.425	(0.349)	0.358	(0.402)
DRR	1.903	(1.012 **)	1.222	(0.711 **)	1.766	(1.047 **)	1.142	(0.735 *)	1.856	(0.495 ***)	1.751	(0.509 ***)
C1WMSD	---	(---)	---	(---)	0.334	(2.038)	1.888	(0.342 ***)	---	(---)	1.905	(0.339 ***)
C1WOTM	---	(---)	---	(---)	0.289	(0.149 **)	0.289	(0.149 **)	---	(---)	0.115	(0.225)
C1WR	---	(---)	---	(---)	-0.045	(0.079)	-0.076	(0.075)	---	(---)	-0.076	(0.025 ***)
DFS3	0.983	(0.653 *)	1.063	(0.650 *)	0.983	(0.653 *)	1.063	(0.650 *)	1.793	(0.803 **)	1.793	(0.803 **)
D940929	---	(---)	66.344	(3.813 ***)	---	(---)	95.840	(4.341 ***)	---	(---)	---	(---)
D950330	---	(---)	116.344	(3.813 ***)	---	(---)	107.141	(2.829 ***)	---	(---)	---	(---)
D950413	---	(---)	31.985	(0.707 ***)	---	(---)	32.217	(0.811 ***)	---	(---)	---	(---)
D950414	---	(---)	23.832	(0.098 ***)	---	(---)	23.832	(0.098 ***)	---	(---)	---	(---)
D950907	---	(---)	37.832	(0.098 ***)	---	(---)	37.832	(0.098 ***)	---	(---)	---	(---)
Sample	875		875		875		875		542		542	
Adj. R^2	0.209		0.775		0.208		0.802		0.142		0.357	

Notes:

1. DMSD denotes the dummy variable that takes a value of one at the time of forecasting for the final day of the settlement month, or one day before the end of either March, September, or December, otherwise zero.
2. DOTM denotes the dummy variable that takes a value of one, one day before the end of either January, February, April, May, June, July, August, October, or November, otherwise zero.
3. DRR denotes the dummy variable that takes a value of one, one day before the final day of the reserve maintenance period each month, otherwise zero.
4. C1WMSD (C1WOTM) denotes a change in one-week call rates from "six day" before the final day of the settlement months (the non-settlement months) to "two day" before, implying tightness in the call market toward the final settlement date.
5. C1WR denotes a change in one-week call rates from "six day" before the final day of the reserve maintenance period to "two day" before, implying tightness in the call market toward the final reserve maintenance day.
6. DFS3 denotes the dummy variable that takes a value of one when there is a fund shortage of more than three trillion yen in the reserve market because of demand for banknotes and the treasury fund transaction on the following day, otherwise zero, implying the tightness of the cash market.
7. DYYMMDD denotes the dummy variable that takes a value of one when the official discount rate is changed on DD/MM/YY, otherwise zero.
8. The figures in parentheses are standard errors adjusted for heteroskedasticity and autocorrelation with one-day lags based on Newey and West [1987].
9. ***, **, and * denote significance levels of 1%, 5%, and 10%, respectively.

Table 2: Biases in Forecasting Errors: Forecasting One-Week Rolling Call Rates Based on One-Week Call Rates

	From Nov. 1, 1988 to Nov. 21, 1997		From Nov. 1, 1988 to Dec. 30, 1994		From Sep. 12, 1995 to Nov. 21, 1997
	W/O policy change dummy	With policy change dummy	W/O policy change dummy	With policy change dummy	
Constant	3.296 (0.391***)	2.989 (0.370***)	3.092 (0.543***)	2.861 (0.530***)	3.651 (0.315***)
DJAN4	1.443 (2.766)	1.750 (2.761)	3.058 (4.016)	3.289 (4.011)	-1.222 (0.315***)
DJAN3	0.386 (2.813)	0.693 (2.803)	1.498 (4.155)	1.730 (4.142)	-1.079 (0.332***)
DJAN2	2.131 (2.734)	2.438 (2.721)	3.833 (3.913)	4.064 (3.893)	-0.008 (1.014)
DJAN1	4.138 (2.698*)	4.611 (2.993*)	6.478 (3.551**)	7.353 (4.077**)	-0.222 (0.844)
DFEB4	-2.439 (1.180**)	-2.132 (1.173**)	-3.212 (1.592**)	-2.980 (1.587**)	-0.222 (0.437)
DFEB3	-2.489 (1.277**)	-2.181 (1.271**)	-3.307 (1.753**)	-3.075 (1.748**)	-0.436 (0.349)
DFEB2	-0.392 (1.523)	-0.085 (1.518)	-0.492 (2.232)	-0.261 (2.228)	0.778 (0.374**)
DFEB1	2.300 (1.539*)	2.607 (1.533**)	3.551 (2.219*)	3.782 (2.215**)	1.385 (0.630**)
DMAR4	70.056 (14.499***)	82.418 (15.893***)	84.463 (18.626***)	97.652 (17.342***)	43.992 (14.740***)
DMAR3	86.053 (16.773***)	93.088 (19.965***)	109.693 (17.914***)	113.275 (21.179***)	42.278 (17.887***)
DMAR2	80.758 (16.717***)	74.746 (18.256***)	104.212 (18.538***)	97.243 (20.778***)	32.992 (11.438***)
DMAR1	24.348 (10.221***)	20.443 (10.961**)	30.794 (14.226**)	24.665 (15.419*)	1.849 (1.161*)
DAPR4	1.852 (1.012**)	2.159 (1.004**)	2.094 (1.339*)	2.325 (1.334**)	1.635 (2.043)
DAPR3	2.978 (2.066*)	3.286 (2.062*)	4.450 (2.951*)	4.681 (2.948*)	0.135 (0.555)
DAPR2	3.237 (2.849)	3.545 (2.846)	4.364 (4.185)	4.595 (4.183)	0.094 (1.030)
DAPR1	3.357 (2.373*)	3.665 (2.370*)	3.906 (3.401)	4.137 (3.399)	2.064 (0.600***)
DMAY4	2.182 (3.222)	-0.844 (0.855)	3.220 (4.787)	-1.715 (1.094*)	-0.151 (0.709)
DMAY3	1.990 (2.831)	-0.629 (0.747)	3.742 (4.083)	-0.399 (1.089)	-0.651 (0.425*)
DMAY2	1.537 (2.030)	-0.477 (1.048)	3.062 (2.739)	-0.096 (1.191)	0.278 (1.780)
DMAY1	1.898 (1.651)	1.045 (1.096)	3.497 (2.161*)	2.033 (1.366*)	0.171 (1.358)
DJUN4	-2.089 (1.426*)	-0.961 (1.330)	-2.282 (1.995)	-0.817 (1.946)	-0.008 (0.622)
DJUN3	-0.567 (1.188)	-0.350 (1.312)	-0.666 (1.534)	-0.639 (1.790)	1.564 (1.186*)
DJUN2	0.923 (1.633)	0.434 (1.612)	0.950 (2.091)	-0.128 (2.025)	2.992 (2.777)
DJUN1	3.342 (2.326*)	1.442 (1.312)	4.639 (3.237*)	1.556 (1.688)	2.349 (2.481)
DJUL4	0.242 (1.082)	0.549 (1.075)	-0.215 (1.496)	0.017 (1.494)	1.635 (1.023*)
DJUL3	-1.445 (1.229)	-1.138 (1.219)	-2.125 (1.674)	-1.894 (1.666)	0.849 (0.703)
DJUL2	-0.640 (1.474)	-0.333 (1.466)	-1.180 (1.798)	-0.948 (1.791)	3.349 (0.325***)
DJUL1	-1.201 (1.198)	-0.894 (1.191)	-1.355 (1.597)	-1.123 (1.593)	1.135 (0.358***)
DAUG4	-2.849 (1.281**)	-2.836 (1.388**)	-4.016 (1.564***)	-4.531 (1.653***)	0.564 (0.903)
DAUG3	-3.061 (1.211***)	-2.637 (1.289**)	-3.740 (1.594***)	-3.499 (1.817**)	-0.365 (0.691)
DAUG2	-3.200 (1.197***)	-2.776 (1.314**)	-3.877 (1.612***)	-3.636 (1.841**)	-0.793 (0.507*)
DAUG1	-0.475 (0.910)	-0.168 (0.891)	0.389 (1.170)	0.620 (1.163)	-1.151 (0.787*)
DSEP4	36.484 (10.668***)	36.792 (10.667***)	51.340 (12.123***)	51.571 (12.120***)	6.826 (3.105**)
DSEP3	35.248 (11.495***)	35.555 (11.495***)	49.033 (14.177***)	49.265 (14.177***)	7.730 (4.259**)
DSEP2	37.611 (11.960***)	37.919 (11.959***)	52.864 (14.330***)	53.095 (14.330***)	7.159 (3.787**)
DSEP1	8.342 (5.014**)	8.649 (5.013**)	12.089 (7.474*)	12.320 (7.475**)	1.492 (1.291)
DOCT4	1.035 (1.631)	1.343 (1.627)	1.446 (2.240)	1.678 (2.238)	0.266 (1.913)
DOCT3	2.753 (2.624)	3.060 (2.622)	4.162 (3.708)	4.393 (3.706)	-0.014 (1.974)
DOCT2	2.730 (2.247)	3.038 (2.243*)	4.085 (3.230)	4.316 (3.227*)	0.073 (0.953)
DOCT1	2.069 (1.712)	2.376 (1.708*)	2.777 (2.381)	3.008 (2.378)	0.707 (1.765)
DNOV4	2.299 (2.456)	2.607 (2.453)	3.510 (3.051)	3.741 (3.048)	-1.579 (0.894**)
DNOV3	3.140 (3.155)	3.448 (3.152)	4.367 (3.959)	4.598 (3.957)	-0.793 (1.333)
DNOV2	5.568 (4.261*)	5.875 (4.259*)	7.181 (5.346*)	7.413 (5.344*)	0.278 (1.481)
DNOV1	11.159 (7.685*)	11.466 (7.684*)	14.332 (9.306*)	14.563 (9.305*)	-0.329 (2.153)
DDEC4	22.318 (8.308***)	19.579 (8.765**)	28.077 (9.710***)	25.171 (10.804***)	2.522 (0.395***)
DDEC3	20.534 (8.216***)	17.148 (8.366**)	25.836 (9.741***)	21.993 (10.470**)	2.336 (0.321***)
DDEC2	22.960 (10.484**)	18.995 (10.883**)	28.743 (12.714**)	24.208 (13.904**)	3.077 (0.369***)
DDEC1	12.952 (10.090*)	13.259 (10.088*)	16.611 (12.332*)	16.842 (12.329*)	-0.361 (0.504)
DRR4	-0.901 (0.884)	-0.843 (0.770)	-1.742 (1.141*)	-1.290 (1.073)	1.158 (0.524**)
DRR3	-0.291 (0.875)	0.134 (0.819)	-0.358 (1.221)	0.233 (1.165)	0.844 (0.605*)
DRR2	0.684 (0.768)	0.819 (0.730)	0.760 (1.052)	1.090 (1.047)	0.897 (0.481**)
DRR1	-0.118 (0.586)	0.140 (0.541)	-0.124 (0.787)	0.223 (0.771)	0.029 (0.408)
D890531-4	--- (---)	23.476 (0.370***)	--- (---)	23.603 (0.530***)	--- (---)
D890531-3	--- (---)	29.998 (0.783***)	--- (---)	30.996 (0.973***)	--- (---)
D890531-2	--- (---)	26.336 (0.659***)	--- (---)	26.235 (0.967***)	--- (---)
D890531-1	--- (---)	20.897 (1.285***)	--- (---)	20.340 (1.344***)	--- (---)
D891011-4	--- (---)	-9.685 (0.370***)	--- (---)	-9.558 (0.530***)	--- (---)
D891011-3	--- (---)	-17.596 (0.370***)	--- (---)	-17.468 (0.530***)	--- (---)
D891011-2	--- (---)	-22.310 (0.370***)	--- (---)	-22.183 (0.530***)	--- (---)
D891011-1	--- (---)	-31.938 (0.712***)	--- (---)	-31.636 (1.002***)	--- (---)
D891225-4	--- (---)	-18.364 (0.370***)	--- (---)	-18.236 (0.530***)	--- (---)
D891225-3	--- (---)	-7.399 (0.370***)	--- (---)	-7.272 (0.530***)	--- (---)
D891225-2	--- (---)	-6.953 (0.370***)	--- (---)	-6.825 (0.530***)	--- (---)
D891225-1	--- (---)	1.663 (0.841**)	--- (---)	1.791 (0.922**)	--- (---)

Table 2 (continued)

	From Nov. 1, 1988 to Nov. 21, 1997		From Nov. 1, 1988 to Dec. 30, 1994		From Sep. 12, 1995 to Nov. 21, 1997
	W/O policy change dummy	With policy change dummy	W/O policy change dummy	With policy change dummy	
D900320-4	--- (---)	-12.218 (0.656***)	--- (---)	-12.362 (0.941***)	--- (---)
D900320-3	--- (---)	-8.348 (0.444***)	--- (---)	-8.302 (0.633***)	--- (---)
D900320-2	--- (---)	-5.361 (0.444***)	--- (---)	-5.316 (0.633***)	--- (---)
D900320-1	--- (---)	19.136 (3.578***)	--- (---)	19.264 (3.592***)	--- (---)
D900830-4	--- (---)	1.083 (0.370***)	--- (---)	1.210 (0.530**)	--- (---)
D900830-3	--- (---)	1.851 (0.370***)	--- (---)	1.978 (0.530***)	--- (---)
D900830-2	--- (---)	2.651 (1.344**)	--- (---)	4.473 (1.577***)	--- (---)
D900830-1	--- (---)	-1.050 (1.253)	--- (---)	-0.062 (1.692)	--- (---)
D910701-4	--- (---)	-7.385 (1.296***)	--- (---)	-7.401 (1.899***)	--- (---)
D910701-3	--- (---)	0.807 (1.273)	--- (---)	1.224 (1.729)	--- (---)
D910701-2	--- (---)	7.167 (1.580***)	--- (---)	7.856 (1.969***)	--- (---)
D910701-1	--- (---)	19.873 (1.637***)	--- (---)	19.887 (1.919***)	--- (---)
D911114-4	--- (---)	4.797 (0.370***)	--- (---)	4.925 (0.530***)	--- (---)
D911114-3	--- (---)	7.476 (0.370***)	--- (---)	7.603 (0.530***)	--- (---)
D911114-2	--- (---)	14.693 (0.756***)	--- (---)	15.268 (1.044***)	--- (---)
D911114-1	--- (---)	5.106 (1.318***)	--- (---)	5.049 (1.499***)	--- (---)
D911230-4	--- (---)	-0.685 (0.370**)	--- (---)	-0.558 (0.530)	--- (---)
D911230-3	--- (---)	27.422 (8.820***)	--- (---)	21.957 (10.880**)	--- (---)
D911230-2	--- (---)	33.238 (8.409***)	--- (---)	28.521 (10.530***)	--- (---)
D911230-1	--- (---)	38.454 (10.924***)	--- (---)	33.369 (13.961***)	--- (---)
D920401-4	--- (---)	-62.639 (15.892***)	--- (---)	-77.745 (17.327***)	--- (---)
D920401-3	--- (---)	-0.041 (19.946)	--- (---)	-20.100 (21.134)	--- (---)
D920401-2	--- (---)	65.569 (18.240***)	--- (---)	43.199 (20.744**)	--- (---)
D920401-1	--- (---)	42.255 (18.451**)	--- (---)	38.162 (21.392**)	--- (---)
D920727-4	--- (---)	0.190 (0.370)	--- (---)	0.317 (0.530)	--- (---)
D920727-3	--- (---)	7.333 (0.370***)	--- (---)	7.460 (0.530***)	--- (---)
D920727-2	--- (---)	10.476 (0.370***)	--- (---)	10.603 (0.530***)	--- (---)
D920727-1	--- (---)	21.190 (1.096***)	--- (---)	21.317 (1.160***)	--- (---)
D930204-4	--- (---)	-4.916 (2.985**)	--- (---)	-7.530 (4.069**)	--- (---)
D930204-3	--- (---)	1.775 (2.985)	--- (---)	-0.839 (4.069)	--- (---)
D930204-2	--- (---)	38.529 (0.370***)	--- (---)	38.657 (0.530***)	--- (---)
D930204-1	--- (---)	27.368 (6.584***)	--- (---)	27.496 (6.595***)	--- (---)
D930921-4	--- (---)	-2.236 (0.444***)	--- (---)	-2.191 (0.633***)	--- (---)
D930921-3	--- (---)	14.199 (0.370***)	--- (---)	14.326 (0.530***)	--- (---)
D930921-2	--- (---)	10.404 (0.370***)	--- (---)	10.532 (0.530***)	--- (---)
D930921-1	--- (---)	7.284 (0.370***)	--- (---)	7.412 (0.530***)	--- (---)
D950331-4	--- (---)	-0.185 (0.370)	--- (---)	--- (---)	--- (---)
D950331-3	--- (---)	-45.853 (15.892***)	--- (---)	--- (---)	--- (---)
D950331-2	--- (---)	-60.505 (19.946***)	--- (---)	--- (---)	--- (---)
D950331-1	--- (---)	-8.690 (15.423)	--- (---)	--- (---)	--- (---)
D950414-4	--- (---)	-4.221 (0.370***)	--- (---)	--- (---)	--- (---)
D950414-3	--- (---)	7.336 (0.756***)	--- (---)	--- (---)	--- (---)
D950414-2	--- (---)	14.056 (0.769***)	--- (---)	--- (---)	--- (---)
D950414-1	--- (---)	25.925 (1.359***)	--- (---)	--- (---)	--- (---)
D950707-4	--- (---)	7.297 (0.370***)	--- (---)	--- (---)	--- (---)
D950707-3	--- (---)	13.440 (0.370***)	--- (---)	--- (---)	--- (---)
D950707-2	--- (---)	18.440 (0.370***)	--- (---)	--- (---)	--- (---)
D950707-1	--- (---)	23.297 (0.496***)	--- (---)	--- (---)	--- (---)
D950908-4	--- (---)	14.154 (0.370***)	--- (---)	--- (---)	--- (---)
D950908-3	--- (---)	21.297 (0.370***)	--- (---)	--- (---)	--- (---)
D950908-2	--- (---)	26.868 (0.370***)	--- (---)	--- (---)	--- (---)
D950908-1	--- (---)	37.104 (1.227***)	--- (---)	--- (---)	--- (---)
Sample	2,248	2,248	1,532	1,532	542
Adj. R^2	0.402	0.458	0.477	0.510	0.489

Notes:

1. DMX denotes the dummy variable that takes a value of one, X days before the end of month M, otherwise zero.
2. DRRX denotes the dummy variable that takes a value of one, X days before the final day of the reserve maintenance period each month, otherwise zero.
3. DYYMMDD-X denotes the dummy variable that takes a value of one when the official discount rate is changed on DD/MM/YY, otherwise zero. X implies the X days before the policy change.
4. The figures in parentheses are standard errors adjusted for heteroskedasticity and autocorrelation with one-week lags based on Newey and West [1987].
5. ***, **, and * denote significance levels of 1%, 5%, and 10%, respectively.

Table 3: Biases in Forecasting Errors: Forecasting One-Month-Ahead One-Month Rates Based on GENSAKI Rates

	From Nov. 1, 1988 to Nov. 21, 1997		From Nov. 1, 1988 to Dec. 28, 1994	
	W/O policy change dummy	With policy change dummy	W/O policy change dummy	With policy change dummy
mJAN1	0.682 (4.926)	-3.914 (3.904)	1.189 (7.375)	-6.052 (6.068)
mJAN2	4.177 (9.450)	-4.096 (5.540)	5.659 (12.787)	-6.190 (7.745)
mJAN3	0.134 (5.104)	-3.779 (3.554)	0.507 (7.789)	-5.705 (5.471)
mJAN4	2.230 (5.669)	-2.332 (3.784)	3.432 (8.452)	-3.560 (5.877)
mFEB1	2.150 (3.977)	-0.276 (3.121)	3.855 (5.839)	0.177 (4.819)
mFEB2	1.410 (2.396)	1.410 (2.396)	2.212 (3.451)	2.212 (3.451)
mFEB3	-0.531 (1.903)	-0.332 (2.005)	-0.611 (2.823)	-0.326 (3.015)
mFEB4	-2.400 (2.478)	-1.562 (2.638)	-3.651 (3.500)	-2.508 (3.974)
mMAR1	2.287 (5.827)	-5.367 (2.469**)	-1.910 (6.240)	-5.782 (3.571*)
mMAR2	3.085 (7.194)	-5.010 (2.445**)	-2.960 (5.898)	-5.208 (3.527*)
mMAR3	4.512 (9.351)	-7.809 (2.935***)	-4.353 (5.834)	-8.399 (3.976**)
mMAR4	1.615 (7.878)	-8.388 (2.822***)	-6.194 (4.116*)	-9.007 (3.978**)
mAPR1	-0.459 (4.313)	-4.641 (1.973***)	-4.215 (2.604*)	-4.215 (2.604*)
mAPR2	-1.493 (2.856)	-3.869 (1.665**)	-3.843 (2.215**)	-3.843 (2.215**)
mAPR3	-3.422 (1.864**)	-3.422 (1.864**)	-4.023 (2.709*)	-4.023 (2.709*)
mAPR4	-3.615 (1.247***)	-3.615 (1.247***)	-4.485 (1.704***)	-4.485 (1.704***)
mMAY1	-1.953 (1.768)	-0.430 (1.462)	-3.975 (1.712**)	-1.963 (1.001**)
mMAY2	-0.706 (1.865)	0.620 (1.414)	-2.715 (2.158)	-0.809 (0.911)
mMAY3	-0.996 (2.186)	0.702 (1.671)	-3.666 (2.199**)	-1.457 (1.127*)
mMAY4	-0.599 (1.636)	-1.277 (1.711)	-1.866 (1.929)	-3.262 (1.909**)
mJUN1	0.665 (2.820)	-1.980 (1.642)	1.817 (4.113)	-2.231 (2.479)
mJUN2	5.522 (5.331)	-1.566 (3.029)	2.677 (5.699)	-1.238 (4.036)
mJUN3	5.540 (5.437)	-2.482 (3.122)	2.998 (6.023)	-2.401 (4.353)
mJUN4	7.832 (6.624)	-5.003 (2.519**)	6.301 (8.555)	-6.549 (3.352**)
mJUL1	7.152 (6.468)	-2.508 (3.333)	4.661 (7.987)	-3.118 (4.616)
mJUL2	2.691 (4.413)	-2.325 (1.710*)	4.151 (6.527)	-3.555 (2.617*)
mJUL3	3.445 (4.814)	-1.842 (1.424*)	5.978 (6.932)	-2.004 (2.079)
mJUL4	-0.139 (2.402)	0.959 (2.126)	0.645 (3.358)	2.431 (2.831)
mAUG1	1.068 (3.421)	3.813 (2.923*)	1.222 (5.038)	5.688 (4.386*)
mAUG2	6.336 (5.960)	7.048 (5.893)	4.870 (8.748)	9.601 (8.267)
mAUG3	7.287 (7.478)	6.139 (7.507)	3.923 (9.778)	6.271 (10.331)
mAUG4	8.536 (7.953)	2.177 (8.346)	6.377 (11.071)	2.175 (11.950)
mSEP1	7.395 (7.615)	0.437 (7.639)	5.926 (10.720)	0.090 (10.748)
mSEP2	-1.188 (4.778)	-2.119 (3.983)	-3.272 (6.925)	-4.283 (6.151)
mSEP3	-5.928 (4.508*)	-3.206 (3.026)	-9.367 (6.235*)	-5.977 (4.587*)
mSEP4	-5.439 (4.132*)	-1.067 (2.090)	-8.602 (5.790*)	-2.269 (3.154)
mOCT1	-5.107 (5.797)	0.464 (2.502)	-8.377 (8.378)	-0.193 (3.872)
mOCT2	-2.496 (4.860)	-1.229 (2.728)	-4.514 (7.106)	-2.955 (4.017)
mOCT3	-1.238 (4.882)	-4.218 (4.492)	-3.078 (7.477)	-8.369 (6.775)
mOCT4	-1.255 (3.932)	-2.790 (3.916)	-3.583 (5.626)	-6.393 (5.531)
mNOV1	3.840 (3.227)	4.115 (3.457)	2.648 (4.494)	2.820 (5.020)
mNOV2	4.213 (3.286*)	4.760 (3.343*)	3.779 (4.607)	4.484 (4.822)
mNOV3	2.330 (2.939)	2.330 (2.939)	2.240 (3.997)	2.240 (3.997)
mNOV4	5.213 (4.126)	2.355 (3.390)	7.155 (5.301*)	3.399 (4.585)
mDEC1	3.682 (7.271)	-4.055 (2.382**)	5.774 (9.197)	-4.075 (3.264)
mDEC2	0.268 (7.202)	-5.440 (3.162**)	1.784 (9.126)	-5.521 (4.283*)
mDEC3	1.362 (7.649)	-5.596 (2.875**)	3.058 (9.906)	-6.174 (4.017*)
mDEC4	1.412 (7.067)	-5.744 (2.495**)	3.118 (8.990)	-6.159 (3.343**)
P890531-1	--- (---)	-13.699 (1.524***)	--- (---)	-12.073 (1.001***)
P890531-2	--- (---)	-14.560 (1.672***)	--- (---)	-12.401 (1.128***)
P890531-3	--- (---)	-8.182 (1.757***)	--- (---)	-6.197 (1.954***)
P891011-1	--- (---)	-31.659 (3.114***)	--- (---)	-29.265 (4.748***)
P891011-2	--- (---)	-41.277 (2.317***)	--- (---)	-40.184 (3.330***)
P891011-3	--- (---)	-52.348 (2.376***)	--- (---)	-51.335 (3.622***)

Table 3(continued)

	From Nov. 1, 1988 to Nov. 21, 1997				From Nov. 1, 1988 to Dec. 28, 1994			
	W/O policy change dummy		With policy change dummy		W/O policy change dummy		With policy change dummy	
D891225-1	---	(---)	-1.634	(2.603)	---	(---)	-2.146	(3.571)
D891225-2	---	(---)	-10.100	(3.203***)	---	(---)	-10.019	(4.311**)
D891225-3	---	(---)	-8.472	(2.734***)	---	(---)	-8.004	(3.772**)
D900320-1	---	(---)	-7.549	(2.659***)	---	(---)	-6.854	(3.681**)
D900320-2	---	(---)	-14.232	(2.359***)	---	(---)	-13.904	(3.437***)
D900320-3	---	(---)	-16.603	(2.405***)	---	(---)	-16.274	(3.404***)
D900830-1	---	(---)	-24.708	(3.768***)	---	(---)	-26.798	(5.371***)
D900830-2	---	(---)	-26.258	(7.009***)	---	(---)	-26.874	(9.627***)
D900830-3	---	(---)	-20.404	(7.535***)	---	(---)	-20.469	(10.636**)
D910701-1	---	(---)	23.801	(3.080***)	---	(---)	24.293	(3.337***)
D910701-2	---	(---)	36.080	(3.013***)	---	(---)	35.950	(4.143***)
D910701-3	---	(---)	38.484	(2.514***)	---	(---)	39.759	(3.385***)
D911114-1	---	(---)	25.111	(3.954***)	---	(---)	28.722	(5.767***)
D911114-2	---	(---)	6.275	(3.692**)	---	(---)	8.955	(4.901**)
D911114-3	---	(---)	-8.765	(3.206***)	---	(---)	-7.979	(4.662**)
D911230-1	---	(---)	71.264	(2.370***)	---	(---)	71.090	(3.241***)
D911230-2	---	(---)	68.125	(2.873***)	---	(---)	68.504	(3.961***)
D911230-3	---	(---)	66.098	(2.461***)	---	(---)	66.540	(3.329***)
D920401-1	---	(---)	34.010	(2.354***)	---	(---)	34.316	(3.431***)
D920401-2	---	(---)	30.058	(2.973***)	---	(---)	30.648	(4.004***)
D920401-3	---	(---)	16.268	(2.774***)	---	(---)	16.882	(3.870***)
D920727-1	---	(---)	45.611	(2.686***)	---	(---)	46.675	(3.455***)
D920727-2	---	(---)	41.152	(1.535***)	---	(---)	42.169	(2.352***)
D920727-3	---	(---)	43.362	(1.444***)	---	(---)	43.525	(2.093***)
D930204-1	---	(---)	41.367	(4.435***)	---	(---)	43.449	(6.283***)
D930204-2	---	(---)	48.065	(3.426***)	---	(---)	49.712	(5.297***)
D930204-3	---	(---)	36.392	(3.761***)	---	(---)	36.779	(5.523***)
D930921-1	---	(---)	37.444	(7.468***)	---	(---)	37.494	(10.636***)
D930921-2	---	(---)	32.290	(5.951***)	---	(---)	33.364	(8.556***)
D930921-3	---	(---)	14.665	(3.460***)	---	(---)	17.133	(5.256***)
D950331-1	---	(---)	46.431	(2.936***)	---	(---)	---	(---)
D950331-2	---	(---)	41.651	(8.689***)	---	(---)	---	(---)
D950331-3	---	(---)	43.959	(8.863***)	---	(---)	---	(---)
D950414-1	---	(---)	35.978	(9.133***)	---	(---)	---	(---)
D950414-2	---	(---)	42.529	(2.775***)	---	(---)	---	(---)
D950414-3	---	(---)	30.294	(1.763***)	---	(---)	---	(---)
D950707-1	---	(---)	37.192	(2.932***)	---	(---)	---	(---)
D950707-2	---	(---)	40.339	(2.508***)	---	(---)	---	(---)
D950707-3	---	(---)	41.324	(3.018***)	---	(---)	---	(---)
D950908-1	---	(---)	22.557	(6.831***)	---	(---)	---	(---)
D950908-2	---	(---)	32.023	(8.347***)	---	(---)	---	(---)
D950908-3	---	(---)	28.273	(6.917***)	---	(---)	---	(---)
Sample	2,218		2,218		1,507		1,507	
Adj. R^2	0.024		0.666		0.029		0.591	

Notes:

1. In this table, the first, the second, the third, and the fourth periods, denoted by the Xth period, imply, respectively, the period of the first five business days in a month, sixth business day to the last day of the reserve maintenance period, the first day of the reserve maintenance period to the sixth business day from the end of the month, and the last five days.
2. mMX denotes the dummy variable that takes a value of one during the Xth period of month M, otherwise zero.
3. DYYMMDD-Z denotes the dummy variable that takes a value of one during the first two weeks (Z = 1), the next one week (Z = 2), or the last week (Z = 3) of the month when the official discount rate is changed on DD/MM/YY, otherwise zero.
4. The figures in parentheses are standard errors adjusted for heteroskedasticity and autocorrelation with one-month lags based on Newey and West [1987].
5. ***, **, and * denote significance levels of 1%, 5%, and 10%, respectively.

Table 4: Biases in Forecasting Errors: Forecasting One-Month-Ahead One-Month Rates Based on Euro Yen TIBOR

	From Jan. 4, 1990 to Nov. 21, 1997		From Jan. 4, 1990 to Dec. 30, 1994	
	W/O policy change dummy	With policy change dummy	W/O policy change dummy	With policy change dummy
mJAN1	5.475 (7.509)	0.023 (5.104)	6.839 (11.924)	-2.264 (8.356)
mJAN2	7.502 (9.320)	-2.564 (4.629)	10.551 (13.633)	-5.380 (7.348)
mJAN3	-0.087 (6.303)	-3.136 (4.874)	-1.257 (10.142)	-6.502 (7.622)
mJAN4	-12.628 (5.703**)	-12.628 (5.703**)	-16.311 (8.212**)	-16.311 (8.212**)
mFEB1	-3.711 (3.172)	-3.711 (3.172)	-5.914 (4.329*)	-5.914 (4.329*)
mFEB2	-2.468 (4.281)	-4.374 (4.219)	-9.109 (4.708**)	-9.109 (4.708**)
mFEB3	-2.718 (5.174)	-5.138 (5.981)	-10.811 (6.447**)	-14.292 (5.882***)
mFEB4	-7.237 (5.212*)	-11.950 (7.109**)	-17.295 (3.116***)	-23.297 (2.727***)
mMAR1	9.989 (5.557**)	2.121 (3.222)	6.637 (5.063*)	0.019 (2.791)
mMAR2	9.056 (6.904*)	-2.235 (1.649*)	3.327 (5.071)	-3.632 (1.943**)
mMAR3	11.723 (9.407)	1.719 (5.143)	2.177 (6.193)	1.613 (6.942)
mMAR4	8.128 (8.641)	8.128 (8.641)	-0.216 (8.930)	-0.216 (8.930)
mAPR1	2.319 (5.831)	2.319 (5.831)	-4.123 (6.836)	-4.123 (6.836)
mAPR2	4.239 (3.622)	4.239 (3.622)	0.432 (4.236)	0.432 (4.236)
mAPR3	3.210 (2.513)	3.210 (2.513)	2.025 (3.600)	2.025 (3.600)
mAPR4	6.246 (3.238**)	6.246 (3.238**)	4.656 (4.631)	4.656 (4.631)
mMAY1	6.837 (3.023**)	6.837 (3.023**)	3.825 (3.368)	3.825 (3.368)
mMAY2	5.224 (3.588*)	5.224 (3.588*)	0.187 (3.744)	0.187 (3.744)
mMAY3	1.802 (3.055)	2.208 (2.825)	-0.949 (4.424)	-0.276 (3.890)
mMAY4	-1.976 (4.207)	-0.693 (3.785)	-3.916 (6.577)	-1.763 (5.589)
mJUN1	3.904 (2.999*)	4.313 (4.349)	6.146 (4.394*)	8.300 (6.006*)
mJUN2	7.951 (5.196*)	1.471 (3.393)	4.643 (6.409)	-1.319 (4.440)
mJUN3	8.365 (6.085*)	1.589 (5.261)	5.434 (8.071)	-5.663 (6.010)
mJUN4	15.308 (6.846**)	13.369 (6.639**)	15.848 (9.849*)	11.533 (9.141)
mJUL1	8.808 (4.748**)	5.324 (4.078*)	6.639 (6.530)	-0.001 (3.958)
mJUL2	4.600 (3.150*)	1.529 (1.849)	5.181 (4.657)	-0.009 (1.955)
mJUL3	6.313 (3.979*)	7.399 (3.914**)	5.604 (4.911)	5.604 (4.911)
mJUL4	-0.148 (5.688)	5.827 (4.925)	-4.734 (7.148)	0.557 (5.713)
mAUG1	5.145 (6.987)	11.501 (6.691**)	1.824 (8.877)	8.438 (8.887)
mAUG2	14.353 (9.780*)	16.611 (9.877**)	10.015 (15.579)	14.301 (15.881)
mAUG3	12.769 (7.273**)	10.278 (9.332)	8.194 (10.142)	5.172 (15.211)
mAUG4	16.014 (8.570**)	14.399 (9.570*)	16.301 (12.986)	13.132 (15.713)
mSEP1	10.279 (6.411*)	9.793 (7.102*)	10.024 (9.326)	9.104 (11.058)
mSEP2	2.588 (6.429)	2.588 (6.429)	3.119 (10.221)	3.119 (10.221)
mSEP3	1.455 (5.351)	1.455 (5.351)	4.183 (8.105)	4.183 (8.105)
mSEP4	4.537 (4.420)	4.537 (4.420)	8.626 (6.390*)	8.626 (6.390*)
mOCT1	3.663 (1.872**)	3.429 (1.726**)	5.380 (2.730**)	4.961 (2.498**)
mOCT2	2.291 (2.347)	1.094 (1.768)	2.495 (3.646)	0.399 (2.777)
mOCT3	-1.563 (1.867)	-2.007 (2.096)	-2.988 (2.937)	-4.133 (3.497)
mOCT4	-2.958 (3.751)	-1.754 (3.966)	-7.177 (4.901*)	-5.920 (5.659)
mNOV1	2.919 (3.462)	3.556 (3.665)	0.155 (4.021)	0.641 (4.637)
mNOV2	4.293 (2.507**)	4.293 (2.507**)	3.044 (3.093)	3.044 (3.093)
mNOV3	5.973 (3.619**)	4.978 (3.792*)	4.604 (4.234)	3.105 (4.505)
mNOV4	6.007 (4.206*)	1.779 (4.748)	6.572 (6.522)	-0.621 (7.886)
mDEC1	2.397 (9.658)	-3.632 (6.459)	3.374 (13.499)	-5.523 (9.159)
mDEC2	3.689 (10.385)	-5.842 (5.480)	4.806 (14.463)	-8.933 (7.517)
mDEC3	7.131 (9.785)	-2.642 (4.426)	9.630 (13.115)	-3.900 (6.445)
mDEC4	6.543 (5.727)	5.566 (6.355)	8.562 (7.839)	7.213 (9.197)
D900320-1	--- (---)	2.549 (6.317)	--- (---)	13.073 (2.838***)
D900320-2	--- (---)	17.050 (3.408***)	--- (---)	19.153 (3.006***)
D900320-3	--- (---)	26.201 (1.679***)	--- (---)	27.598 (1.971***)
D900830-1	--- (---)	-36.679 (5.926***)	--- (---)	-33.068 (8.265***)
D900830-2	--- (---)	-42.772 (9.319***)	--- (---)	-39.343 (15.029***)
D900830-3	--- (---)	-1.771 (9.985)	--- (---)	2.695 (15.393)

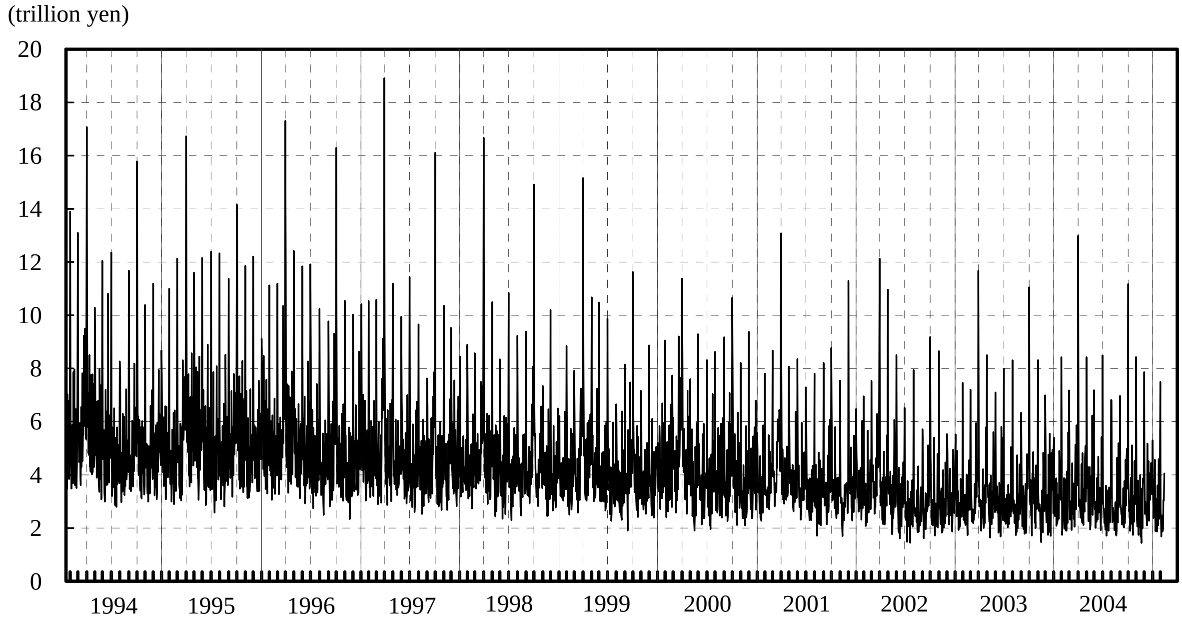
Table 4 (continued)

	From Jan. 4, 1990 to Nov. 21, 1997		From Jan. 4, 1990 to Dec. 30, 1994	
	W/O policy change dummy	With policy change dummy	W/O policy change dummy	With policy change dummy
D910701-1	--- (---)	-9.967 (6.667*)	--- (---)	-10.768 (6.407**)
D910701-2	--- (---)	30.597 (3.531***)	--- (---)	33.387 (4.542***)
D910701-3	--- (---)	41.347 (5.105***)	--- (---)	47.697 (5.919***)
D911114-1	--- (---)	9.338 (2.823***)	--- (---)	10.480 (3.269***)
D911114-2	--- (---)	-11.803 (3.026***)	--- (---)	-8.453 (4.310**)
D911114-3	--- (---)	-6.368 (3.593**)	--- (---)	-3.036 (4.775)
D911230-1	--- (---)	33.823 (8.925***)	--- (---)	35.967 (10.440***)
D911230-2	--- (---)	75.727 (5.575***)	--- (---)	78.577 (7.642***)
D911230-3	--- (---)	68.808 (4.376***)	--- (---)	70.371 (6.310***)
D920401-1	--- (---)	8.802 (5.994*)	--- (---)	16.936 (3.106***)
D920401-2	--- (---)	7.764 (2.205***)	--- (---)	9.443 (2.098***)
D920401-3	--- (---)	3.410 (4.004)	--- (---)	3.947 (5.138)
D920727-1	--- (---)	7.248 (6.617)	--- (---)	12.038 (7.140**)
D920727-2	--- (---)	27.871 (4.246***)	--- (---)	33.196 (4.131***)
D920727-3	--- (---)	23.544 (1.849***)	--- (---)	25.081 (1.955***)
D930204-1	--- (---)	6.837 (5.857)	--- (---)	6.746 (7.697)
D930204-2	--- (---)	52.811 (4.895***)	--- (---)	55.204 (7.954***)
D930204-3	--- (---)	52.854 (4.466***)	--- (---)	55.945 (7.053***)
D930921-1	--- (---)	20.450 (9.428**)	--- (---)	24.313 (14.933*)
D930921-2	--- (---)	18.875 (9.004**)	--- (---)	21.677 (14.851*)
D930921-3	--- (---)	4.867 (7.364)	--- (---)	5.749 (11.609)
D950331-1	--- (---)	14.869 (4.934***)	--- (---)	--- (---)
D950331-2	--- (---)	-2.990 (11.407)	--- (---)	--- (---)
D950331-3	--- (---)	15.417 (10.257*)	--- (---)	--- (---)
D950414-1	--- (---)	25.774 (11.754**)	--- (---)	--- (---)
D950414-2	--- (---)	55.091 (3.954***)	--- (---)	--- (---)
D950414-3	--- (---)	69.421 (5.149***)	--- (---)	--- (---)
D950707-1	--- (---)	-0.300 (3.518)	--- (---)	--- (---)
D950707-2	--- (---)	11.357 (5.462**)	--- (---)	--- (---)
D950707-3	--- (---)	27.353 (3.534***)	--- (---)	--- (---)
D950908-1	--- (---)	-18.462 (4.653***)	--- (---)	--- (---)
D950908-2	--- (---)	2.998 (9.447)	--- (---)	--- (---)
D950908-3	--- (---)	20.368 (9.064**)	--- (---)	--- (---)
Sample	1,950	1,950	1,234	1,234
Adj. R^2	0.066	0.353	0.072	0.347

Notes:

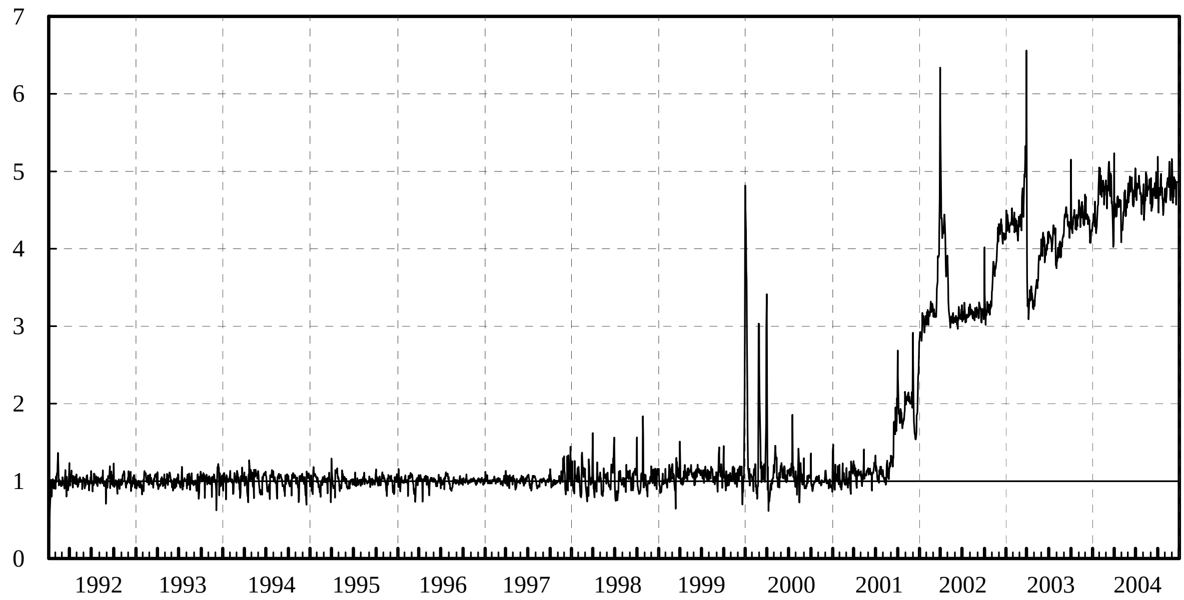
1. In this table, the first, the second, the third, and the fourth periods, denoted by the Xth period, respectively, imply the period of the first five business days in each month, sixth business day to the last day of the reserve maintenance period, the first day of the reserve maintenance period to the sixth business day from the end of the month, and the last five days.
2. mMX denotes the dummy variable that takes a value of one during the Xth period of month M, otherwise zero.
3. DYYMMDD-Z denotes the dummy variable that takes a value of one during the first two weeks (Z = 1), the next one week (Z = 2), or the last week (Z = 3) of the month when the official discount rate is changed on DD/MM/YY, otherwise zero.
4. The figures in parentheses are standard errors adjusted for heteroskedasticity and autocorrelation with one-month lags based on Newey and West [1987].
5. ***, **, and * denote significance levels of 1%, 5%, and 10%, respectively.

Figure 1: BOJ Account Settlements for the Bill and Check Clearing System and the Domestic Fund Transfer System



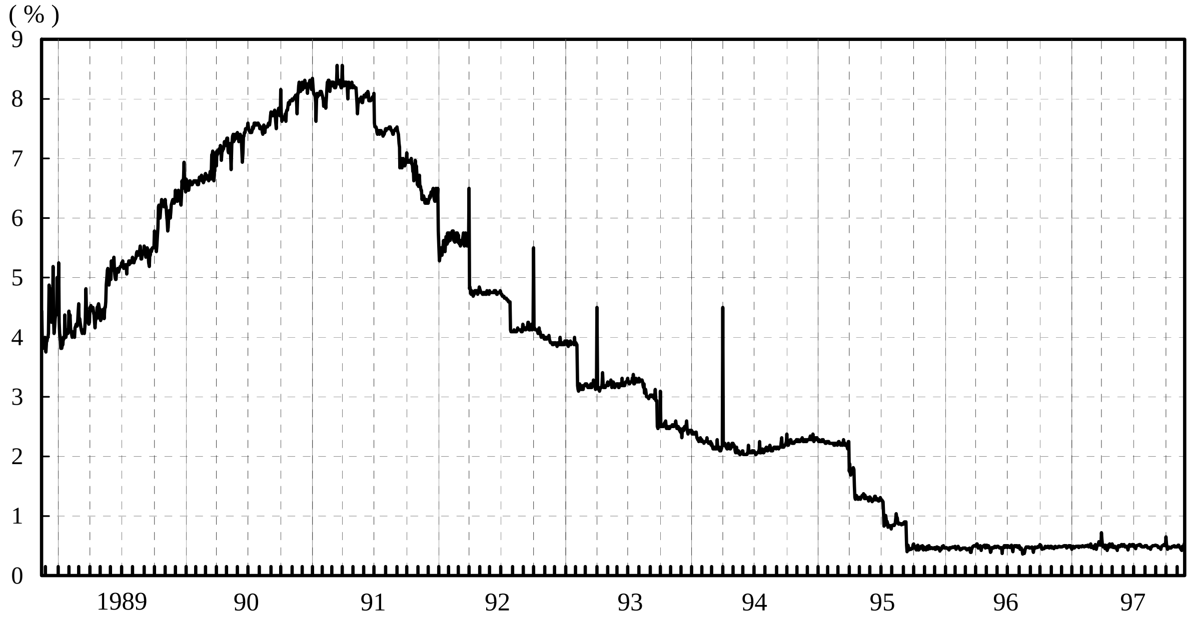
Source: Bank of Japan, *Financial and Economic Statistics Monthly*, various issues.
Notes:
1. The figures are sums of the daily flow of the two systems settled through the BOJ reserve account.
2. The vertical solid and dotted lines indicate the end of the year and end of the quarter, respectively.

Figure 2: Ratio of Reserve Balance to Required Reserves



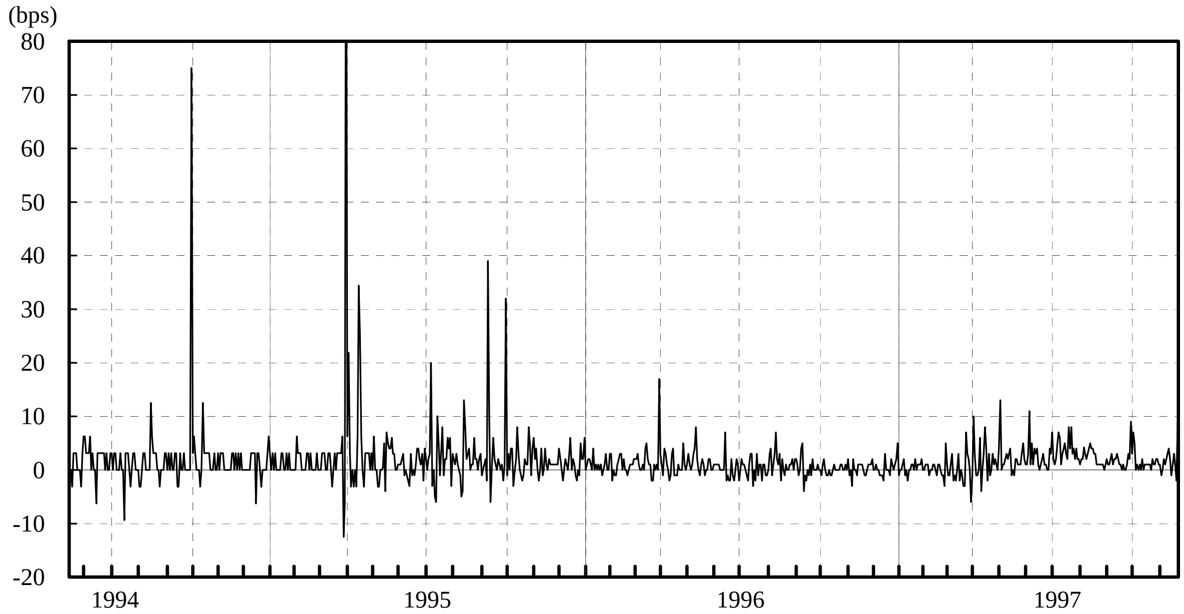
Source: Bank of Japan, *Financial and Economic Statistics Monthly*, various issues.
Notes:
1. The figures are the ratios of the realized reserve balance to the required reserve. The reserve maintenance period is from the 16th of a month to 15th of the following month.
2. The vertical dotted lines indicate the end of each year.

Figure 3: Uncollateralized Overnight Call Rates



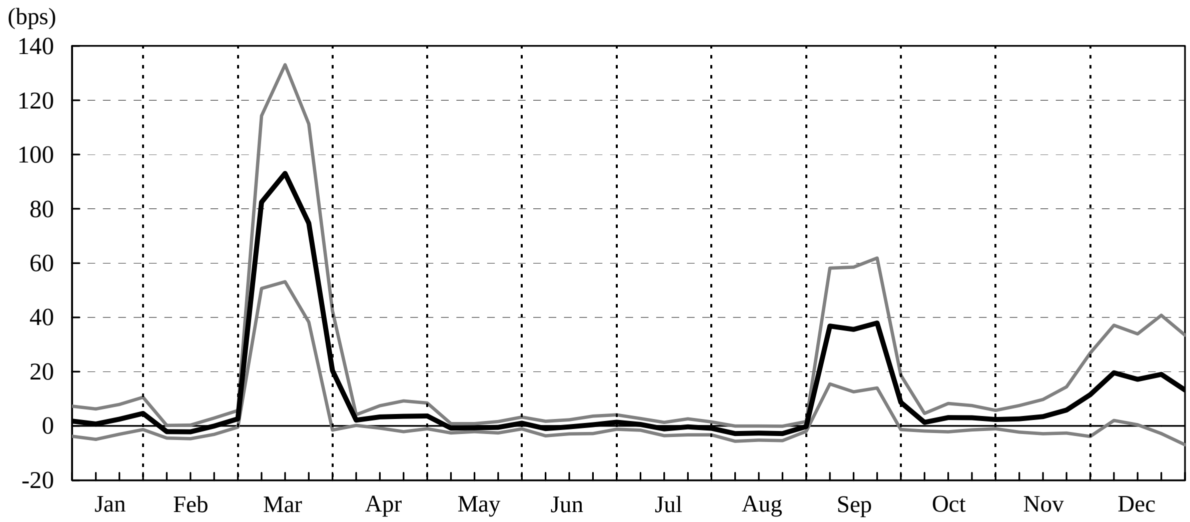
Source: Bank of Japan, *Financial and Economic Statistics Monthly*, various issues.
Notes: The vertical solid and dotted lines indicate the end of the year and end of the quarter, respectively.

Figure 4: Forecasting Errors for One-Day-Ahead Overnight Rates Based on Tomorrow-Next Transactions



Source: Bank of Japan, *Financial and Economic Statistics Monthly*, various issues.
Notes: The vertical solid and dotted lines indicate the end of the year and end of the quarter, respectively.

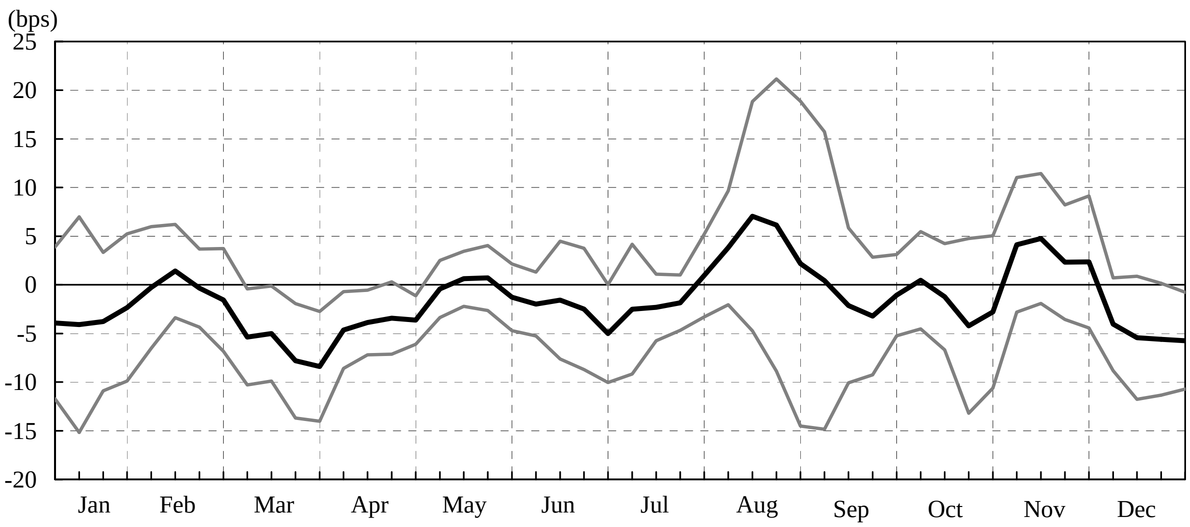
Figure 5: Biases in Forecasting Errors for One-Week Rolling Call Rates Based on One-Week Call Rates during Last Four Days of Each Month



Notes:

1. This figure plots the estimates of coefficients on DMX (where M is from January through to December, and X is from four to one) in the estimation including policy change dummies based on the sample period from November 1988 to November 1997 (see Table 2).
2. The vertical dotted lines indicate the end of each month.
3. The shaded lines correspond to the values derived from adding and subtracting two standard errors for each estimated parameter.

Figure 6: Biases in Forecasting Errors for One-Month Ahead One-Month Rate in GENSAKI



Notes:

1. This figure plots the estimates of coefficients on mMX (where M is from January through to December, and X is from the first period to the fourth) in the estimation including policy change dummies based on the sample period from November 1988 to November 1997 (see Table 3).
2. The vertical dotted lines indicate the end of each month.
3. The shaded lines correspond to the values derived from adding and subtracting two standard errors for each estimated parameter.