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Financial Crises as the Failure of Arbitrage: Implications for Monetary Policy

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Abstract

This paper attempts to view financial crises as the failure of arbitrage among financial markets, and takes the 'Japan premium' phenomenon observed in offshore money markets as an important example in favor of this view. In addition, we reconsider, from this perspective, the open market operations conducted by a central bank during a period of financial distress. The paper first derives from the existing theoretical literature several implications regarding how arbitrage among markets is prevented when financial institutions such as investors and intermediaries suffer from severe liquidity constraints, and then examines empirically such theoretical implications using the data available from offshore money markets. Given these implications, explored both theoretically and empirically, the paper finally discusses a possible role played by a central bank in recovering market liquidity when markets are segmented in the absence of financial arbitrage.

Key words: Financial market instability; Japan premium; Allocation of liquidity; Failure of arbitrage; Money market operation

JEL Classification Code: E44, E58, G14

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I. Introduction

Since the fall of 1997, market participants as well as policy makers had been seriously concerned over the stability of the Japanese financial system for several reasons.[1] First, the successive failures of major Japanese financial institutions in November 1997 aggravated the market concern about the credit and liquidity risk of Japanese financial institutions. Second, a recurrent rumor as to the troubled Long-Term Credit Bank of Japan (LTCB) markets in June 1998 generated adverse sentiments about Japanese financial. Third, a deep concern over a possible credit contraction in global markets was aroused in the summer and fall of 1998. Both the Russian financial crisis and the financial difficulty faced by a major US hedge fund came to the attention of market participants, thereby promoting the shift of funds from risky investment opportunities to safer and more liquid assets such as US government bonds.

In this paper, we examine how severely major Japanese banks were financially constrained in 1997 and 1998, and how the behavior of such troubled banks affected the asset pricing mechanism during these financial crises. In particular, we interpret the phenomena caused by financial crises as deviations from either efficient intertemporal allocation or effective arbitrage among financial markets.

Our interpretation of financial crises is based heavily on the recent development of financial economics concerning asset pricing in extreme circumstances. In this literature, researchers have paid serious attention to the impact on asset pricing, of the liquidity constraint that both investors such as institutional investors and hedge funds, and intermediaries such as banks and market makers, face during financial crises. Such liquidity constraints may prevent market players, including investors and intermediaries, from conducting arbitrage efficiently or making markets effectively; accordingly, asset pricing may be seriously and persistently distorted, and financial crises may be prolonged more than is bearable. Shleifer and Vishny (1997), for example, show that asset prices may collapse in illiquid markets due to the failure of arbitrage during financial crises.

Based on the above perspective on financial crises, we examine empirically several theoretical implications of the failure of arbitrage using the data available from offshore inter-bank money markets or Eurocurrency markets. Arbitrage conditions we consider to be likely to fail during financial crises include (1) the parity conditions for

[1] Mori, Shiratsuka, and Taguchi (2000) review the financial and economic development in the 1990s, and analyze the policy response of the Bank of Japan, with a particular emphasis on the impact of the bursting of the asset price bubbles.

various financial instruments, and (2) the forecastability of future returns based on the standard expectations hypothesis.

The financial data obtained from offshore money markets are fairly desirable in terms of our research purpose. First, offshore money markets serve as a marginal short-term financing device for most major commercial banks. Second, offshore money markets are less subject to domestic monetary intervention. Accordingly, we may observe in purer form the liquidity needs that originate from Japanese commercial banks in such marginal markets. In other words, it is rather easy to find from the offshore pricing data how seriously major financial intermediaries were facing liquidity constraints during the financial crises of 1997 and 1998.

The ‘Japan premium’ phenomenon is the most representative irregular pricing that was observed in offshore money markets during the financial crises. The ‘Japan premium’ literally means how higher return Japanese banks have to pay for short-term borrowing than their US and European competitors. That is, it is the extra short-term financing cost for major Japanese banks. The phenomenon represented by this term has been regarded frequently as a symbol of the financial crises of 1997 and 1998. As discussed in detail later, the ‘Japan premium’ phenomenon indeed reflected a complicated mixture of the poor creditworthiness of the entire banking sector and the individual characteristics of major commercial banks. In addition, to which extent the ‘Japan premium’ was serious depended on the government intervention.[2]

Given the theoretical and empirical implications of financial crises explored as discussed above, we attempt to extract some policy implications for the conduct of open market operations by a central bank during a period of financial distress. In particular, we explore some possibilities that a central bank may play an important role in recovering market liquidity by means of money market operations when financial markets are severely segmented in the absence of arbitrage during financial crises. In this regard, we reconsider the fairly complicated operations conducted in various money markets by the Bank of Japan (BOJ) during the crisis, in particular their simultaneous open market purchases in long-term money markets and sales in short-term money markets.

This paper is organized as follows. Section II demonstrates several striking facts regarding the performance of the inter-bank offshore markets. Then, Section III briefly reviews the theoretical literature to extract some implications for the behavior of

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[2] Peek and Rosengren (1999), for example, point out that the size of the Japan premium tended to be affected by policy announcements together with the concrete actions taken by the Japanese government such as public injections of funds into the banking system.

financial institutions suffering from severe liquidity constraints during financial crises, and Section IV empirically examines some of the theoretical implications based on the offshore money market data. On the basis of theoretical and empirical examination in the preceding sections, Section V discusses several issues regarding monetary policy, in particular open market operations, during financially stressed situations. Section VI concludes the paper.

II. The 'Japan Premium' and the Financial Crises in 1997 and 1998

In this section, we investigate various aspects of the 'Japan premium' phenomenon, thereby showing that such a premium reflected not only the serious financial constraints faced by the Japanese banking sector as a whole, but also the individual characteristics of major Japanese banks.[3] In addition, we examine in which respect the 1997 financial crisis differed from the 1998 crisis.

The calculation of the 'Japan premium' explored by this paper is based on the individual quotes from the contributor panel of the banks which were referred in computing the LIBOR. Among major Japanese banks, we focus on the Bank of Tokyo-Mitsubishi (BTM) and the Fuji Bank. These two banks were the only Japanese financial institutions that were included in the LIBOR panel for both dollar and yen contracts before 1998. The 'Japan premium' is then defined as the difference between the inter-bank lending rate quoted by these two banks and the average of the rate quoted by the non-Japanese banks included in the LIBOR panel.[4]

The above two Japanese banks were contrastive in 1997 and 1998; the BTM was one of the healthiest banks, while the Fuji was considered to be relatively troubled. Therefore, the observed difference in the 'Japan premium' between the two is expected to reflect the gap in their creditworthiness. While the premium differed only slightly between the two banks before the fall of 1997, it indeed varied from each other substantially during the Japanese financial crisis in 1997 and 1998.

A. The Characteristics of the 'Japan Premium'

In the period between 1997 and 1998, the 'Japan premium' phenomenon appeared in the late fall of 1997 for the first time, and between the summer and the fall of 1998 for

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[3] The 'Japan premium' must have been caused by not only the credit condition faced by Japanese banks, but also the enhanced risk aversion of major investors including institutional investors. While the latter factor is obviously important, it is not explored in detail by this paper.

the second time. Figure 1 and Figure 2 plot the 'Japan premium' that appeared in spot rates of dollar and yen contracts using the BTM quote (upper panels) and the Fuji quote (lower panels). With respect to the 'Japan premium' in one-month dollar contracts, the BTM quote reached a peak at 112.8 basis points on December 3 and 4, 1997, and at 40.6 basis points on November 27, 1998. In the case of the Fuji quote, the premium peaked at 125.3 basis points on December 3, 1997, and at 58.8 basis points on November 30, 1998.

The 'Japan premium' phenomenon appeared in the yen market as well. The one-month yen contract quoted by the BTM showed the highest premium by 103.8 basis points on December 3, 1997, and by 58.4 basis points on November 30, 1998. In the case of the Fuji quote, the premium peaked at 116.3 basis points on December 3, 1997, and 64.6 basis points on November 27, 1998. According to Table 1, the 'Japan premium' was even more serious in dollar markets than in yen markets. The mean of the 'Japan premium' is higher in dollar markets than in yen markets, regardless of maturity, the BTM or the Fuji, or the 1997 crisis or the 1998 crisis.

In what follows, we compare the 1997 crisis with the 1998 crisis, and carefully examine how these crises differed from each other. First, the 'Japan premium' was generally larger in the second crisis than in the first crisis. As Table 1 shows, for both the BTM and the Fuji, the mean of the 'Japan premium' is higher in the 1998 crisis than in the 1997 crisis, except for one-month maturity contracts. In particular, the mean of longer maturity dollar contracts quoted by the Fuji during the 1998 crisis is remarkably high.

Second, the premium difference between the two banks was more eminent in the 1998 crisis. This property is illuminated by Figure 3, which plots the implied default rates[5] derived from yen LIBOR on the vertical axis and those derived from dollar LIBOR on the horizontal axis. The case of the 1997 (1998) is described in the upper (lower) panel. By construction, larger default rates correspond to larger 'Japan premiums.' Consistently with the preceding findings, in both cases of the BTM and the Fuji, all observations stay under the 45-degree line, while they are located farther away from the 45-degree line in the 1998 crisis. In addition, the finding that the observations of the Fuji are farther below the 45-degree line in the lower panel suggests that the Fuji faced more severe financing conditions in dollar markets than the BTM during the 1998

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[4] Our definition of the 'Japan premium' follows what Peek and Rosengren (1999) define.

[5] The implied default rate P is computed as $P = (R\text{-}r)/(1+R)$, where R is a one-year LIBOR quote for individual banks, and r is a one-year risk-free rate (one-year TB yield). This formula presumes the zero recovery rate in the case of default as well as the risk-neutrality on the part of lenders.

crisis. In the next subsection, we investigate in more detail how the ‘Japan premium’ was influence by the individual characteristics of Japanese banks.

Third, the ‘Japan premium’ moved very differently in maturity or between yen and dollars during the 1998 crisis, while it co-moved among various contracts in the 1997 crisis. Table 2 shows the correlation coefficient of the ‘Japan premiums’ among contracts with various maturities. In the 1997 crisis, the correlation is generally high among contracts; the coefficient is larger than 0.7 for any pair. In the 1998 crisis, on the other hand, the correlation coefficient is insignificant in the case between dollars and yen as well as the case between one-month contracts and longer-term contracts. In the latter case, the correlation coefficient is negative. These findings suggest that the ‘Japan premium’ moved very differently among various contracts during the 1998 crisis.

Using the ‘Japan premium’ appearing in the implied forward rate (IFR), we can see the above phenomenon from a different angle (see Figure 4 and Figure 5). The ‘Japan premium’ observed in the IFR increased simultaneously among contracts with different starting points immediately after the failure of Yamaichi Securities in November 1997. During the 1998 crisis, however, the ‘Japan premium’ observed in the IFR reflected to larger extent the financial needs for the calendar year-end and fiscal year-end funding. More concretely, an increase in the one-month IFR based on three-month contracts in September 1998, was followed by an increase in that based on two-month contracts, and then an increase in the one-month spot rate, by turns with one month intervals. This tendency suggests that the premium on borrowing contracts which would mature beyond the calendar year-end was even larger.

In sum, the ‘Japan premium’ phenomenon differed substantially between the 1997 crisis and the 1998 crisis. In particular, the ‘Japan premium’ depended more on the individual characteristics of banks during the 1998 crisis. In the next subsection, we further investigate the difference in the ‘Japan premium’ among major Japanese banks using the panel data of yen contracts.

B. Panel Data Analysis of the ‘Japan Premium’

In this subsection, we explore the premium difference among Japanese banks in more detail employing the daily panel data of the ‘Japan premium’ of yen contracts and the stock price of individual banks. By focusing on yen contracts, we can construct the panel data consisting of six Japanese commercial banks. In the subsequent empirical analysis, we use the individual stock price as a proxy for the funding capacity; higher stock prices mean larger funding capacity. Under this maintaining assumption, we quantify how much the ‘Japan premium’ depended on the individual characteristics of banks, in particular the funding capacity.

1. Data and Specification

The 'Japan premium' used in this subsection is again based on the individual quotes from the LIBOR contributor panel in yen contracts. Focusing on yen contracts, this panel consists of six major commercial banks, that is, Sumitomo Bank, Dai-ichi Kangyo Bank (DKB), Industrial Bank of Japan (IBJ), and Sanwa Bank in addition to the BTM and the Fuji.[6] Daily closing prices on the Tokyo Stock Exchange (TSE) are used as the stock price data. Note that the stock prices are determined before the LIBORs are fixed; the daily LIBOR is fixed at 11:00 a.m. London time, corresponding to 8:00 p.m. in Tokyo, considerably after the closure of the TSE.[7]

Constructing 60 consecutive business days as a sub-sample period, we divide the whole sample period between 1997 and 1998 into the following five sub-sample periods:

(1) the period before the first crisis (between August 4, 1997 and November 4),
(2) the period during the first crisis (between November 25, 1997 and February 26, 1998),
(3) the period between the two crises (between March 9, 1998 and June 8),
(4) the period during the second crisis (between September 10, 1998 and December 8), and
(5) the period after the second crisis (between June 9, 1999 and September 1).

We estimate two-way panel data models to describe the 'Japan premium' observed in one-year yen contracts (JP_{it})[8] using the stock prices of individual banks relative to the TOPIX of the banking sector ($SP_{it}/TPXBNK_t$), individual effects (α_i), and time effects (γ_t) as explanatory variables, or the following specification:

$$JP_{it} = \alpha_i + \gamma_t + \beta \ln\left(SP_{it} / TPXBNK_t\right) + \varepsilon_{it}.$$

The above two-way panel data setting flexibly allows for various specifications as

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[6] While Norinchukin Bank is also included in the LIBOR panel of yen contracts, the equity price is not readily available for this bank. The TIBOR panel of yen contracts additionally covers Asahi Bank, Long-term Credit Bank, Mitsui Trust Bank, Mitsubishi Trust Bank, Sakura Bank, Sumitomo Trust Bank, Tokai Bank, and Yasuda Trust Bank. The database of the TIBOR panel however records only the data observed after 1998, and it is not suitable for our comparison between the two crises.

[7] During the summer time (from the last Sunday in March to the last Sunday in October), the time difference between Tokyo and London is shortened by one hour; the LIBOR fixing time corresponds to 7:00 p.m. in Tokyo.

[8] We choose one-year yen contracts as dependent variables to control for the calendar effect such as the calendar year-end funding and the fiscal year-end funding.

special cases. When the individual effect is constant over time and the time effect is common among banks ($\alpha_i = \alpha$ and $\gamma_t = \gamma$), the above equation reduces to the pooling OLS model. It corresponds to the one-way panel data model when it allows for only the individual effect. Among these specifications, the coefficient on the relative stock price is assumed to be constant. In both the one-way and two-way panel data models, either the individual effect or the time effect can be either fixed or random; therefore, there are four possible combinations for the specification of both individual and time effects.

Among the above possible specifications, we employ the following five specifications: the pooling OLS model, the one-way fixed/random models, and the two-way fixed/random models. Given these specifications, we conduct three types of hypothesis tests as follows.[9] First, the pooling OLS model is tested against the one-way and two-way fixed effect models based on the *F*-test of the estimated individual and time effects. Second, Lagrange Multiplier (LM) tests the pooling OLS model against the random effect model. Third, the random effect model is tested against the fixed effect model on the basis of a Hausman-type specification test.

2. Estimation Results

Table 3 summarizes the estimation results for the five sub-sample periods.[10] The most striking finding is that the 'Japan premium' behaved fairly differently in the period during the second crisis compared with the other four sub-sample periods.

First, for the latter sub-samples, the significantly negative coefficient on the relative stock price (β) indicates that less healthy credit conditions implied by lower stock prices would lead to larger premiums. In other words, the credit risk played an important role in determining the 'Japan premium.' As mentioned later, however, the coefficient on the relative price for the subsample period during the second crisis is significantly positive.

Second, the fixed effect model is selected against the random effect model for both (1) the subsample periods between crises and (2) during the second crisis, while the random effect model is selected for other subsample periods. One interpretation of these results is that market participants became more sensitive to the differences in creditworthiness of individual banks as the Japanese financial system lost credibility

[9] See Green (1999) for the detail of the specification test for the panel data models.

[10] We use the web-based program DECOMP to adjust trading-day effects in stock prices. We also employ the heteroskedasticity robust procedure proposed by White (1980) to compute standard errors of parameter estimates.

during the financial crises. Such discrimination of the credit risks across the Japanese banks may lead to a change in the individual-specific component from random effects to fixed effects. That is, the credit risk was so different among the six banks both between the crises and during the second crisis, that the premium difference was explained by mainly the fixed individual effect.

Third, one puzzling finding is that there is a positive relationship between the 'Japan premium' and the movement in stock prices. While this finding may suggest that there was a substantial difference in opinion of market participants between domestic stock markets and offshore money markets, it would be rather difficult to identify specific factors responsible for this puzzling phenomenon.

C. Background Argument for the Premium Difference

As examined in the preceding subsections, the 'Japan premium' behaved fairly differently between the first crisis and the second crisis. During the 1998 financial crisis, the overall 'Japan premium was even larger, while the 'Japan premium' was influenced to greater extent by the individual characteristics of banks. In this subsection, we point two important factors that might have been responsible for the characteristics of the 'Japan premium' observed during the 1998 crisis.

First, the negative assessment of the Japanese economy might have raised the overall 'Japan premium.' To pursue this possibility, we regard the sovereign risk of the Japanese government as a proxy for the risk involved in the Japanese economy. Figure 6 plots, as the measure of the sovereign risk, the spread on the yield of the dollar-dominated bond issued by the Japan Bank for International Cooperation over the yield on the US Treasury bond (JBIC spread).[11] As this figure clearly shows, there is a high correlation between the 'Japan premium' and the overall risk involved in the Japanese economy in the fall of 1998. This suggests that the 'Japan premium' that emerged during the 1998 crisis reflected partly the poor credit condition of the Japanese economy as a whole. After the spring of 1999, however, the JBIC spread had remained high, although the 'Japan premium' disappeared; it seems that the factor specific to large government deficits continued to be reflected in larger sovereign risk.[12]

Second, one important change occurred between the two crises, that is, the decision of the Government of Japan to inject public funds.[13] In March 1998, the

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[11] The JBIC is a government financial institution with a mandate to implement the external economic policy and international cooperation. The Government of Japan owns the JBIC fully, and explicitly guarantees the bond and notes issued by the JBIC.

[12] For the detail of the budget condition of the Japanese government, see Fujiki (2000).

[13] Between 1998 and 1999, the Government of Japan made the public fund injection into private banks to

government injected public funds, though small sized, into major banks for the first time. Then, the government set up the large-scale public fund to stabilize the financial system in October 1998, although the public fund was actually injected in March 1999. One possible initial impact of the decision to inject public money was facilitating discrimination of credit risk across banks, rather than stabilizing the concern in financial markets. The estimation results reported in the preceding subsection may pick up this aspect of the public injection. After the government injected public funds for the second time in collaboration with the zero interest rate policy in March 1999, the public money injection finally seemed to contribute to buffering the Japanese banking system generally.

In the subsequent sections, we interpret structurally the 'Japan premium' appearing in both spot rates and implied forward rates, instead of finding casually facts from the observed premium as we have done so far. In particular, applying the existing theoretical models surveyed in Section III, we extract empirically the information about the liquidity of money and currency markets from the observed 'Japan premium' in Section IV, and explore possible implications for monetary policy in Section V.

III. Liquidity Risks and the Behavior of Financial Institutions

In this section, we briefly review the existing theoretical literature on the propagation mechanism of exogenous shocks through financial market transactions. Our particular interest lies in the case where financial institutions such as investors and intermediaries that suffer from liquidity constraints as a consequence of realized adverse shocks, are forced to give up reasonable financial transactions, including profitable investment opportunities, efficient market making, and gainful arbitrage opportunities. Such liquidity-constrained behavior of financial institutions may have seriously negative impacts on asset pricing, and consequently upon dynamic resource allocation.

In particular, the activities of commercial banks, on which we are focusing in this paper, are influenced heavily by their liquidity constraints. As is well known, financial institutions have to keep financing to maintain not only their investment activities but also their market making and arbitraging. On the one hand, as financial intermediaries

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strengthen the capital base twice. In March 1998, around ¥1.8 trillion was injected into 21 major banks. After expanding the public fund in October 1998, the government injected ¥7.5 trillion additionally into 15 major banks, and ¥2.6 billion into four regional banks in March 1999. The first inject was too insufficient in size to yield favorable results for the credit condition. After the second large-scale injection was made in collaboration with the zero interest rate policy, the 'Japan premium' disappeared completely.

banks finance funds from both depositors and institutional investors, and invest in bank loans. On the other hand, as market makers, they deal in various financial instruments, including financial derivatives of interest rates and foreign currency, by finding sellers and buyers among their customers. In addition, as experts in domestic and foreign currency markets, banks continuously exploit arbitrage opportunities in these financial markets. Therefore, liquidity constraints, once such constraints are binding among banks, adversely affect a wide range of banking activities.

A. Possible Causes of Exogenous Adverse Shocks

Before reviewing specific models of liquidity constraints, we add one comment regarding this class of economic model. In most cases, an initial negative impact is treated as an exogenous shock rather than as an endogenous one. In literature of macroeconomics, a typical adverse shock is a negative productivity shock. Such negative shocks reduce corporate profits directly and lower labor wages indirectly.

In finance literature, an adverse shock is often represented by an exogenous sharp decline in asset prices. A separate body of models in financial economics can explain at least partially why such a drop in asset prices takes place in financial markets. One of the most successful explanations is that unexpected decreases in asset prices are caused by the realization of hedge demand implicitly built into synthetic derivatives. In contrast with derivative contracts traded publicly on exchanges, the volume of synthetic derivatives, often traded over the counter, is extremely difficult for market participants to grasp correctly. Difficulties with measuring the market size of synthetic derivatives make asset prices fail to reflect the size of hedge demand in advance, and cause asset prices to crash in response to the unexpected realization of hedge demand. Grossman (1988), Gennotte and Leland (1990), and others construct models of hidden hedge demand according to the above idea.

Alternatively, a wild swing of asset prices may be caused by excess liquidity on the part of financial institutions. Aggressive purchases from excessively leveraged financial institutions may raise asset prices far above fundamentals. In this case, a price crash can be regarded as the process whereby asset prices converge suddenly and rapidly to economic fundamentals. While excessively leveraged institutions distorted asset pricing in commodity exchanges on some occasions (Williams, 1995), aggressive investment activities made by highly leveraged hedge funds such as the Long Term Capital Management had adverse impacts on illiquid financial markets, which had been targeted as their long positions, in a similar manner.

B. Liquidity Constraints and Banking Activities

It has been well recognized that the asymmetry of information between lenders and borrowers is at least partially responsible for liquidity constraints on the side of borrowers. Williamson (1987), following Townsend (1979), shows that a simple debt contract is optimal when outside investors (lenders) cannot observe internal cash flows, and that creditors charge a credit premium on such loan contracts to compensate for default risk. When borrowers rely too much on outside financing in this form of loan contract, even a large credit premium may not compensate completely for default risk, and accordingly outside lenders become extremely reluctant to lend funds to such borrowers.

One of the implications immediately available from the above theoretical result is that if adverse technological shocks reduce profits and make firms more dependent on outside financing, then such firms are more likely to face liquidity constraints. Obviously, a severe liquidity constraint leads immediately to a negative impact on the corporate spending activity. This important implication has been examined in depth, both theoretically and empirically, in the macroeconomic literature on credit channels.

Bernanke and Gertler (1995) explain that frictions in financial markets, such as imperfect information and costly enforcement of contracts, generate a difference in costs between external funds such as bond financing, and internal funds such as retaining earnings. They call the above wedge the external finance premium, and emphasize that the external finance premium fluctuates coincidentally with business cycles, thereby propagating the conventional effect of interest rates on aggregate demand.[14]

Asymmetric information, however, is not the sole reason for liquidity constraints. Even without any asymmetric information between borrowers and lenders, collateral is often demanded for loan contracts to enforce the repayment of loans by borrowers. In the case of a collateralized loan, the amount of borrowing is severely limited by the market value of the assets used as collateral. A substantial decline in asset prices, consequently, constrains the financing ability of potential borrowers, and forces them to give up profitable investment opportunities.

As shown in Kiyotaki and Moore (1997), given a negative productivity shock in an economy, liquidity constraints caused by lower asset prices persistently lead to inactive investment activities, while weaker demand for assets brought about by depressed investment has a negative impact on asset prices. That is, asset prices and investment activities interact with each other through the effect of collateral value.

Because commercial banks are involved in raising finance for their own loan

[14] Bernanke, Gertler, and Gilchrist (1996) refer as the financial accelerator, to the propagation mechanism

activities, the above mechanism of liquidity constraints, motivated by either information asymmetry or the enforcement constraint, is naturally applicable to banks themselves. What is more, financial institutions require continuous money-financing to maintain their activities of market making and arbitraging; consequently, the liquidity constraint faced by financial institutions has a negative impact on not only on loan activities, but also on market making and professional arbitraging.

As Shleifer and Vishny (1992) show, for example, once leveraged financial institutions such as hedge funds are subject to liquidity constraints, they are forced to give up arbitrage opportunities, and asset prices consequently fail to recover to fundamentals. In their model, the asymmetry of information between financial institutions and outside investors is responsible for liquidity constraints. Because outside investors tend to base their lending decisions not on the current performance of funds, but on their track records, they immediately withdraw funds from investment funds in response to one-time serious losses on those same funds.

As one possible implication from their model, once the banking sector is subject to a liquidity constraint, its professional arbitrage behavior in the money and currency markets may be severely hindered, and asset prices may reflect the failure of arbitrage. On such occasions, standard arbitrage conditions, which would otherwise hold, is likely to break down in the absence of professional arbitrageurs.

As mentioned above, dealers also rely on liquidity in making markets. In a normal situation where they are well financed, dealers charge a premium as a part of the bid-ask spread to compensate for non-diversifiable risks specific to their holdings of inventories. As documented in some empirical studies on bid-ask spreads on financial trading, such inventory costs account for only a part of observed bid-ask spreads (see Glosten and Harris, 1988; George, Kaul, and Nimalendran, 1991; and Huang and Stoll, 1996), while the effect of inventory stocks on bid-ask spreads is not necessarily significant (see Madhavan and Smidt, 1991; Manaster and Mann, 1996).

When asset prices suddenly decline, however, the inventory cost is substantially high because the inventory of assets is accumulated quickly in sellers-dominant financial markets. Consequently, dealers charge large bid-ask spreads to compensate for extremely costly inventories, while they have to rely largely on external financing to reserve cash for absorbing large-scale selling orders. On some occasions, dealers withdraw from market making activities due to cash shortage. In the absence of market makers, then, financial markets may become illiquid and asset prices may fail to recover

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brought about by changes in credit market conditions.

to fundamentals.

C. Liquidity Demand and Asset Pricing

Not only the current liquidity constraints, but also the future possibility of liquidity constraints may have an important impact on asset pricing through its effect on liquidity demand. In preparation for future liquidity constraints, agents may reserve financing devices in advance by holding deposits, investing in safe bonds, keeping lines of credit, reserving loans, or using other methods. Among such financing devices, a bond maturing just at the timing of a liquidity event is the most desirable asset for meeting future liquidity needs.

Holmström and Tirole (1998) demonstrate that, given the possibility of liquidity constraints in the near future, agents have a stronger incentive to hold short-term bonds as liquidity demands. Consequently, the price of short-term bonds becomes higher, and the short-term return is therefore low relative to the long-term return. In other words, the future possibility of liquidity constraints makes the yield curve rather steeper.

More concretely, Holmström and Tirole (1998) show that even if agents are risk-neutral, the standard expectations hypothesis of the term structure fails to hold in the presence of liquidity demand, and the following inequality is available:

$$E_t r_{t+i,j-i} < \frac{j}{j-i} r_{t,j} - \frac{i}{j-i} r_{t,i} \,,$$

where E_t is the expectation operator conditional on the information available at time t, and $r_{t,i}$ is the i -period holding return observed at time t. The above inequality implies that current yield spreads tend to overestimate future yields because of strong liquidity demand for shorter-term bonds in preparation for a liquidity event at time $t+i$. The more likely liquidity constraints will be binding, the more seriously current yield spreads overestimate future yields.[15]

D. Financial Crises as the Failure of Arbitrage

The preceding discussion suggests that the liquidity constraint faced, either currently or in the near future, by commercial banks during financial distress may be reflected in current asset pricing in the following two ways: (1) the deviation of arbitrage or parity conditions as the failure of professional arbitrage, and (2) the failure of the expectations

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[15] With the Japanese money market data, Saito, Yanagawa, and Watanabe (2000) examine the same empirical implication of the term structure, identifying the periodical accounting settlement among Japanese firms as the liquidity event, and find evidence in favor of this implication.

hypothesis as a result of the influence of liquidity demand. As shown in Section IV, these two methods are preferred to the conventional measure of market liquidity such as bid-ask spreads in investigating the effect of the 'Japan premium' phenomenon on market liquidity.

In the next section, we use the asset price data available from offshore money markets to examine empirically the above theoretical implications for asset pricing mainly for the following reasons. First, major commercial banks as professional arbitrageurs play exclusively in offshore money markets. Second, offshore money markets serve as the marginal source of financing for commercial banks. Third, domestic money markets may be more subject to active monetary operations than offshore markets. As discussed later, for the period our empirical research is interested in, the Bank of Japan indeed worked actively on domestic money markets by conducting the so-called 'dual operation.'[16]

Accordingly, the liquidity constraint faced by commercial banks is reflected more directly in these offshore markets. It by no means implies that the performance of domestic money markets is not subject to the liquidity constraint of commercial banks, but that it is fairly possible to observe in even purer form the liquidity impact on asset pricing among offshore markets than among domestic markets.

IV. Evidence for the Failure of Arbitrage

In this section, we examine empirically several implications of the failure of arbitrage, in particular the effect of poor arbitraging on asset prices, using the data available from the offshore inter-bank money market. Based on theoretical models discussed in the preceding section, arbitrage conditions we consider to be likely to fail during financial crises include (1) the parity conditions for various financial instruments, (2) the forecastability of future returns based on a simple expectations hypothesis. In the sense that poor arbitraging would lead to illiquid financial markets, it follows that the above investigations measure the degree in which markets are liquid.

Before reporting empirical results, we point out that the conventional measures of market liquidity such as bid-ask spreads fail to precisely reflect the impact of the 'Japan premium' on the market liquidity. Figure 7 plots the bid-ask spread that the BTM

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[16] The so-called 'dual operation' is defined as the simultaneous purchases and sales in the money market operations conducted by the BOJ. More concretely, the BOJ injected reserves by purchasing money market instruments with relatively long maturities such as year-end and fiscal year-end funding, while they absorbed reserves by selling bills with short maturities. We examine several implications of the 'dual operation' in more detail in Section V.

quoted in the Japan Offshore Market (JOM). The bid-ask spread expanded immediately after the failure of Yamaichi Securities in November, 1997, and continued to be large throughout 1999. It means that the spread observed in the yen offshore money market was still large even after the ‘Japan premium’ phenomenon disappeared. In other words, the period of large bid-ask spreads did not coincide exactly with the emergence of the ‘Japan premium’ phenomenon.[17] This poor performance of the conventional liquidity measure would justify our empirical investigation based on the theory of financial crisis.

A. Deviation of Market Swap Rates from Parity Rates

First of all, we examine the deviation of the market rate for a dollar/yen swap contract from the theoretical rate or the parity rate.[18] As investigated in Section II, the ‘Japan premium’ emerged in both yen and dollar markets. In this sense, the investigation of dollar/yen swap synthesizes the information concerning the ‘Japan premium’ that appeared in both currency markets

The parity rate for a yen/dollar swap contract that promises to buy dollars now and to buy yen later, $SWAP^*_t$ is proportional to the difference in money market rates between yen and dollars. More precisely, it is defined as follows:

$$SWAP_t^* = S_t \times [\exp(r_t^Y - r_t^D) d_t - 1],$$

where r^Y_t is the interest rate of yen, r^D_t is the interest rate of dollars, d_t is the period to maturity, and S_t is the spot rate of foreign exchange expressed in units of yen per dollar. The deviation of the market rate $SWAP_t$ from the above parity is defined as DEV_t, or

$$DEV_t = SWAP_t - SWAP_t^*.$$

Given the above definition, a negative DEV_t implies richness in dollar and cheapness in yen in terms of spot currency markets, or richness in yen and cheapness in dollar in terms of forward markets. In other words, when DEV_t is negative, arbitrageurs can exploit an opportunity of arbitrage by buying yen and selling dollars in spot markets. Conversely, when investors have to keep dollar positions for some reason, they cannot exploit the above opportunity of arbitrage.

The upper panel of Figure 8 plots DEV_t using one-month and three-month

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[17] Because of the Y2K problem, the bid-ask spread expanded again at the end of 1999.

[18] Our analysis developed in this subsection benefits from Hanajiri (1999) which viewed the collapse of parity condition in yen/dollar swap markets as the realization of the ‘Japan premium’ phenomenon.

dollar/yen swap contracts. Both measures indicate that the deviation was largely negative when the ‘Japan premium’ emerged in 1997 and 1998, and that the deviation was close to zero otherwise. In other words, the parity condition for yen/dollar swap failed to hold for the period of the ‘Japan premium.’

As shown below, the above deviation observed during the financial crises is statistically significant. Based on the estimation of the following specification by rolling regressions with subsamples of 50 business days,

$$DEV_t = \alpha + \varepsilon_t ,$$

where α, and ε_t indicate a constant term, and an error term respectively, the middle and lower panels of Figure 8 add the 95% confidence interval for the estimated deviation DEV_t.[19] These figures indicate that the deviation is statistically significant for the period of the ‘Japan premium’ in 1997 and 1998.

How the deviation was serious, however, differs between the 1997 crisis and the 1998 crisis. The deviations implied by the one-month contract peaked in November 1997, and the deviation became smaller in the fall of 1998. In contrast, the deviation calculated from the three-month contract was larger and more persistent in the second crisis than in the first crisis. The parity condition failed most seriously for longer-term swap contracts made during the 1998 crisis.

As mentioned before, a negative deviation implies relative richness in spot dollars. Why did market participants give up such an opportunity of arbitrage in the offshore money markets? As Hanajiri (1999) suggests, both Japan and foreign commercial banks were reluctant to sell dollars and buy yen in spot markets for the following reasons. First, Japanese banks suffered seriously from the shortage of dollars during the financial crises mainly because uncollateralized dollar loans were no longer available for those banks rated as poor credit conditions. They consequently had to keeps dollar positions relying on dollar/yen swap transactions, or borrowing dollars against yen as collateral. Such Japanese banks in serious need for dollars could not exploit the above opportunity at all.

Second, it was rather difficult for non-Japanese banks to find safe places to invest in yen during the financial crises. Before 1999, the money market of treasury bills (TBs) and financing bills (FBs) had been premature due to the limited outstanding of these short-term government securities. Regarding the FB market, the public auction

[19] We employ the procedure proposed by Newy and West (1987) with a Bartlett window and a bandwidth

system of the FB issuance was yet to be introduced, and most FBs were subscribed by the BOJ at the time of their issuance. As a result, the FB market emerged only temporarily when the BOJ conducted sales operation of FBs with repurchase agreement. Although TBs were issued in a public auction, the outstanding was rather small. Due to active purchases of TBs by foreign investors in the autumn of 1998, TB rates declined remarkably with the shortage of TBs, showing even negative rates in the TB market. Accordingly, foreign banks had only a week incentive to keep yen positions by selling dollars although they carried ample dollar positions. The absence of safe yen-dominated assets left the above opportunity of arbitrage unexploited in the offshore markets.

B. Liquidity Demand and Yield Curves

In this subsection, we explore the effect on asset pricing, of forthcoming liquidity needs created by Japanese banks during the financial crises. As discussed in Section III, the possibility that liquidity constraints may be binding in the near future makes agents invest in a shorter-term by borrowing in a longer-term. Such liquidity needs create simultaneously the demand for short-term bond and the supply of long-term bond, and makes short-run bond more expensive and long-run bond cheaper. As Holmström and Tirole (1998) discuss, consequently, it generates steeper yield spreads, thereby breaking the expectations hypothesis of the term structure. More concretely, due to the above liquidity demand, current yield spreads tend to overestimate future spot rates. In what follows, we apply this implication to the offshore market data.

Under the expectations hypothesis, the implied forward rate (IFR), or the steepness of a yield curve corresponds to the expectation of a future spot rate. The forecasting error at time t FE_t is then defined as follows:

$$FE_t = IFR^{1M}_{t-i} - SR^{1M}_t ,$$

where $IFR^{1M}_{t\text{-}i}$ is the implied forward rate, or the one-month rate that is expected i month in advance before time t, while SR^{1M}_t is the one-month spot rate prevailing at time t. Given the above definition, the liquidity demand caused by forthcoming liquidity needs makes FE_t positive, because it leads to the overestimation of the IFR.

Using the IFRs computed from the LIBOR quotes of the BTM and the Fuji, as well as the average LIBOR quotes of non-Japanese banks, we estimated the following

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of 20, to adjust for the heteroskedasticity and autocorrelation of error terms.

specification by rolling regressions with subsamples of 50 business days: [20]

$$FE_t = \alpha + \varepsilon_t ,$$

where α, and ε_t denote a constant term and an error terms respectively. Based on this estimation, Figure 9 plots the estimated α with the 95% confidence interval. Each date on the horizontal axis denotes the end of the 50 business days used by the above rolling regression.

As predicted theoretically, the forecasting error for Japanese banks is significantly positive during the financial crises. Note that the underestimation observed from the end of 1997 to the beginning of 1998 reflects the unexpected rise in short-term rates that was caused by the financial accident including the failure of Yamaichi Securities.[21] On the other hand, the forecasting error for non-Japanese banks is close to zero, except for the Russian crisis in 1998 and the Y2K problem at the year-end 1999.[22]

A closer look at the estimation result offers the following observations as well. First, the overestimation is more serious in dollar contracts than in yen contracts, and for the Fuji than for the BTM. It means that the liquidity demand was stronger for less healthy banks, and that asset pricing was affected to larger extent by the liquidity demand in the dollar markets where Japanese banks suffered from more serious liquidity constraints. Second, the extent to which yield spreads overestimate future spot rates is greater in the 1998 crisis than in the 1997 crisis. This finding suggests that the liquidity demand driven by the financial crisis was even stronger in the second crisis than in the first.

V. Policy Reactions to Financial Crises

As theoretically predicted and empirically documented in the preceding sections, the behavior of banks was adversely affected by their liquidity constraint during the

[20] We employ the procedure proposed by Newy and West (1987) with a Bartlett window and a bandwidth of 20, to adjust for the heteroskedasticity and autocorrelation of error terms.

[21] Similarly, the overestimation observed in yen markets in 1995 reflects the lagged adjustment in market expectations after the unexpected decrease in short-term rates that was caused by the rapid appreciation of yen.

[22] Regarding the Y2K problem, there is an interesting contrast between yen and dollars; the forecasting error for yen contracts is not statistically significant for either Japanese or non-Japanese banks, while that for dollar contracts is statistically significant for both Japanese and non-Japanese banks. One interpretation of this finding is that the ample provision of liquidity by the BOJ made liquidity shortage less serious in yen markets. In other words, the forecasting error reflects the limited funding capacity of

financial crises in 1997 and 1998, and the serious liquidity constraint prevailing in the banking sector resulted in depressed loan activities, limited arbitraging, and poor market making in financial markets, including money and currency markets. Consequently, financial markets were segmented in the absence of the arbitraging and market making that would have been exercised properly by the banking sector. Such a propagation mechanism that the liquidity-constrained behavior of private banks would lead to illiquid financial markets may carry several important implications for the monetary policy conducted by a central bank during financial crises.

A central bank usually attempts to control overnight interest rates, in particular overnight inter-bank rates by guiding the expectations borne by market participants through daily open market operations.[23] In a normal situation, then, once the overnight rate is set at a level desirable from the perspective of monetary policy, a central bank expects the thus-determined overnight rate to be transmitted to other longer-tem interest rates through the financial arbitrage made by private investors and financial institutions. As mentioned repeatedly, the banking sector is one of the most important institutions in arbitraging and dealing in money and currency markets.

During financial crises, however, the above transmission mechanism is unlikely to work properly because the behavior of banks, commercial banks in particular, is severely limited by their liquidity constraint. Financially stressed banks tend to have serious difficulties with lending, arbitraging, and dealing. As a consequence, policy-targeted interest rates or inter-bank overnight rates may fail to be transmitted to other longer-term interest rates.

Thus, it is important for a central bank to intervene in various financial markets to fix segmented markets, thereby recovering market liquidity and restoring the proper transmission mechanism. In this sense, the monetary operation motivated by the above consideration may be rather different from that conducted in a normal situation. That is, the monetary operation should require not only the expansion of the aggregate amount of liquidity available in money markets through lowering short-term interest rates, but also the control of the allocation of liquidity among financial markets, thereby transmitting the policy-targeted short-term interest rate to the returns on other financial instruments.

From the above perspective, the money market operations conducted by the BOJ in 1997 and 1998 are interpretable as motivated by both the sufficient provision of

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individual banks in dollar markets, but not in yen markets.

[23] See Okina (1993), and Miyanoya (2000) for details of the framework of the money market operations conducted by the BOJ.

liquidity, and the proper allocation of liquidity among segmented markets.[24] Figure 10 shows the development of the uncollateralized overnight call rate, which had been the money market rate targeted by the BOJ since 1995. In late November 1997, the call rate rose suddenly, and reached far above the official discount rate of 0.5 percent due to the successive failures of major Japanese financial institutions. In response to this tight condition of money markets, the BOJ supplied ample liquidity, and consequently the call rate was again slightly below the official discount rate in early December 1997. Because the Japanese economic condition had not recovered by September 1998, the BOJ decided to further ease monetary policy by guiding the uncollateralized overnight call rate toward 0.25 percent.

In the dimension of the allocation of liquidity among markets, the BOJ intervened in several money markets simultaneously, thereby fixing the market segmentation. Figure 11 describes the monetary operation conducted by the BOJ between 1996 and 2000. It depicts purchases by a positive number and sales by a negative number. As this figure clearly shows, the BOJ had implemented simultaneous purchases and sales in their monetary operations, the so-called ‘dual operation,’ since the fall of 1997. The amount of sales operations even dominated that of purchases operations as either the end of the fiscal year 1998 or March 1999 approached.

Under the ‘dual operation,’ the BOJ had injected reserves by purchasing in seller-dominant money markets for longer maturity that served as year-end and fiscal year-end funding instruments, while the BOJ had absorbed reserves by selling bills with shorter maturity. By means of this ‘dual operation,’ the BOJ attempted to flatten the steep yield curves, which was eminent in the offshore money market during the financial crises, as documented empirically in Section IV.[25]

More concretely, the above dual operation served mainly for the following two purposes. First, the BOJ attempted to provide ample funds by making purchases from those who wanted to issue bonds which would mature beyond the calendar year-end or the fiscal year-end. Figure 12 plots the purchase operation that would mature beyond the end of each year between 1996 and 1998. This figure shows that the BOJ provided aggressively year-end funds during the periods of the financial crisis.

Second, the BOJ tried to absorb liquidity by outright sales of BOJ bills, in

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[24] For the discussion on the monetary operations during the financial crisis, see Sasaki, Yamaguchi, and Hisada (2000).

[25] In a speech on February 8th 1999, Kazuo Ueda, BOJ Policy Board Member, referred to this dual operation as a kind of operational twist, which was expected to curb upward pressure in the term structure of interest rates.

particular non-Japanese banks, who sought safe places to invest in yen.[26] As discussed in Section IV, the scarcity of safe yen assets kept non-Japanese banks from arbitraging between yen and dollars, and consequently yen markets were segmented from dollar markets. In this regard, the 'dual operation' was expected to recover the liquidity of yen markets by encouraging foreign banks to trade in the yen/dollar swap market.

In sum, what the monetary operation conducted by the BOJ during the financial crises of 1997 and 1998 intended was, first of all, to lower overnight money market rates by supplying ample liquidity, and then to reduce overall interest rates, from short-term to long-term, by fixing segmented money markets through the dual operation. This policy experience suggests that not only the amount of liquidity, but also the allocation of liquidity should be taken care of during a financial crisis where money markets are severely segmented in the absence of efficient arbitraging and market-making.

VI. Conclusions

This paper has attempted to view financial crises as the failure of arbitrage among financial markets, and taken the 'Japan premium' phenomenon observed in offshore money markets as an important example in favor of this view. The paper first derived from the existing theoretical literature several implications regarding how arbitrage among markets is prevented when financial institutions such as investors and intermediaries suffer from severe liquidity constraints, and then examined the theoretical implications empirically using data available from offshore money markets.

We have found that, as theoretically predicted, the behavior of banks was severely constrained by their liquidity constraint during the financial crises that occurred in 1997 and 1998, and that the serious liquidity constraint prevailing in the banking sector resulted in depressed loan activities, limited arbitraging, and poor dealing among financial markets, including the money and currency markets. Consequently, asset pricing was distorted seriously and financial markets were segmented severely.

Given the implications explored theoretically and empirically, the paper finally discussed a possible role played by a central bank in recovering market liquidity when financial markets are segmented in the absence of arbitrage. Pointing out that such a financial crisis propagated by the liquidity-constrained behavior of banks would carry

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[26] In order to make this sales operation more effective, the BOJ set the due date of operations at 1:00 p.m. when most settlements and clearings were made among financial institutions including non-Japanese banks.

several policy implications, we have argued that the monetary policy conducted by the BOJ in 1997 and 1998 is justifiable on these grounds. In particular, the ‘dual operation’ together with easing monetary policy contributed to reducing overall money market rates, from short-term to long-term, by connecting the money markets which otherwise would have been segmented severely in the absence of private arbitraging.

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Table 1: Summary Statistics for the 'Japan premium' in the Financial Crises

	Bank of Tokyo-Mitsubishi				Fuji Bank			
	1M	3M	6M	1Y	1M	3M	6M	1Y
Fall of 1997: November 3, 1997 – February 27, 1998								
[Dollar markets]								
mean	35.4	49.7	43.6	32.5	40.0	62.9	52.7	40.2
max	112.8	101.0	100.0	79.2	125.3	113.5	112.5	102.1
min	0.7	8.0	5.9	6.3	3.1	9.4	5.9	3.1
stdv.	27.1	18.1	18.5	15.1	28.6	22.0	23.2	19.5
[Yen markets]								
mean	34.5	44.5	39.2	30.7	39.6	55.4	48.8	38.8
max	103.8	92.5	85.0	76.3	116.3	108.1	100.6	91.3
min	3.1	3.1	5.6	5.6	3.1	3.1	5.6	5.6
stdv.	24.2	17.9	16.0	12.3	27.7	22.7	20.3	16.6
Fall of 1998: September 1 – December 31, 1998								
[Dollar markets]								
mean	24.4	45.9	53.0	51.4	38.0	69.4	81.9	76.5
max	40.6	69.1	72.2	71.9	58.8	106.6	109.4	100.1
min	5.2	22.1	32.2	28.5	8.3	43.9	52.9	41.0
stdv.	10.1	12.2	11.2	9.3	11.5	14.9	15.2	12.6
[Yen markets]								
mean	27.0	41.5	44.0	39.6	33.9	53.3	60.8	56.0
max	58.4	62.0	62.0	55.5	64.6	80.7	83.9	75.0
min	14.7	24.4	30.0	26.6	19.4	30.7	37.5	32.9
stdv.	8.8	11.4	9.6	7.9	8.6	14.0	13.6	12.1

Table 2: Correlation across Various Contracts

	Bank of Tokyo-Mitsubishi								Fuji Bank							
	Dollar contracts				Yen contracts				Dollar contracts				Yen contracts			
	1M	3M	6M	1Y	1M	3M	6M	1Y	1M	3M	6M	1Y	1M	3M	6M	1Y
Fall of 1997: November 3, 1997 – February 27, 1998																
Dollar BTM																
1M	1.000	0.843	0.888	0.850	0.956	0.747	0.827	0.794	0.982	0.701	0.841	0.810	0.970	0.710	0.827	0.877
3M		1.000	0.968	0.924		0.951	0.959	0.930		0.937	0.951	0.915		0.929	0.960	0.937
6M			1.000	0.978			0.962	0.924			0.971	0.940			0.947	0.959
1Y				1.000				0.895				0.955				0.940
Yen BTM																
1M	0.956	0.855	0.885	0.841	1.000	0.788	0.861	0.808	0.953	0.706	0.837	0.762	0.988	0.737	0.841	0.871
3M		0.951	0.895	0.852		1.000	0.953	0.943		0.953	0.880	0.863		0.973	0.950	0.922
6M			0.962	0.942			1.000	0.957			0.943	0.904			0.971	0.963
1Y				0.895				0.924				0.885				0.959
Dollar FUJI																
1M	0.982	0.844	0.867	0.815	0.953	0.771	0.813	0.798	1.000	0.735	0.822	0.796	0.972	0.745	0.819	0.865
3M		0.937	0.867	0.826		0.953	0.896	0.875		1.000	0.893	0.887		0.976	0.927	0.866
6M			0.971	0.963			0.943	0.871			1.000	0.958			0.956	0.927
1Y				0.955				0.885				1.000				0.921
Yen FUJI																
1M	0.970	0.860	0.892	0.850	0.988	0.786	0.852	0.795	0.972	0.732	0.860	0.798	1.000	0.759	0.855	0.882
3M		0.929	0.855	0.811		0.973	0.908	0.882		0.976	0.870	0.858		1.000	0.943	0.887
6M			0.947	0.923			0.971	0.908			0.956	0.918			1.000	0.961
1Y				0.940				0.938				0.921				1.000
Fall of 1998: September 1 – December 31, 1998																
Dollar BTM																
1M	1.000	0.135	0.102	0.408	0.292	-0.180	-0.206	-0.148	0.737	-0.136	-0.103	0.535	0.524	-0.061	-0.023	0.028
3M		1.000	0.954	0.591		0.899	0.881	0.886		0.880	0.875	0.472		0.930	0.908	0.892
6M			1.000	0.699			0.883	0.893			0.904	0.516			0.916	0.896
1Y				1.000				0.432				0.752				0.555
Yen BTM																
1M	0.292	-0.275	-0.276	-0.214	1.000	-0.190	-0.208	-0.272	0.413	-0.299	-0.318	-0.357	0.878	-0.362	-0.336	-0.379
3M		0.899	0.864	0.361		1.000	0.977	0.941		0.938	0.916	0.229		0.944	0.913	0.865
6M			0.883	0.390			1.000	0.974			0.924	0.232			0.925	0.876
1Y				0.432				1.000				0.302				0.914
Dollar FUJI																
1M	0.737	-0.208	-0.202	0.160	0.413	-0.420	-0.428	-0.392	1.000	-0.366	-0.305	0.313	0.591	-0.338	-0.293	-0.255
3M		0.880	0.840	0.379		0.938	0.911	0.893		1.000	0.934	0.336		0.919	0.895	0.862
6M			0.904	0.550			0.924	0.918			1.000	0.477			0.961	0.936
1Y				0.752				0.302				1.000				0.518
Yen FUJI																
1M	0.524	-0.359	-0.359	-0.174	0.878	-0.356	-0.376	-0.418	0.591	-0.415	-0.390	-0.117	1.000	-0.419	-0.381	-0.397
3M		0.930	0.914	0.493		0.944	0.943	0.938		0.919	0.948	0.426		1.000	0.976	0.952
6M			0.916	0.546			0.925	0.929			0.961	0.466			1.000	0.985
1Y				0.555				0.914				0.518				1.000

Table 3: Stock Prices and the 'Japan premium'

(1) Before the Crises: August 5, 1997 – October 31, 1997

[Regression results]

	Pooled OLS	One-way model		Two-way model	
		Fixed effects	Random effects	Fixed effects	Random effects
Constant	6.099 (16.330)***	---	6.165 (13.722)***	5.739 (6.843)***	10.748 (3.634)***
Stock price	-0.953 (-2.500)**	-3.360 (-2.524)**	-1.022 (-2.229)**	-0.580 (-0.668)	-0.758 (-1.886)*
R-squared	0.017	0.040	---	0.820	---

[Specification tests]

	One-way model	Two-way model
F test (Pooled vs. Fixed effects)	1.70 [0.133]	20.21 [0.000]***
F test (One-way vs. Two-way fixed effects)	---	21.63 [0.000]***
LM test (Pooled vs. Random effects)	0.00 [0.969]	519.82 [0.000]***
Hausman test (Random Effects vs. Fixed effects)	15.38 [0.000]***	0.08 [0.781]

(2) During the First Crisis: November 25, 1997 – February 26, 1998

[Regression results]

	Pooled OLS	One-way model		Two-way model	
		Fixed effects	Random effects	Fixed effects	Random effects
Constant	48.272 (27.231)***	---	46.383 (14.294)***	45.860 (31.518)***	46.286 (20.692)***
Stock price	-6.902 (-3.778)***	7.498 (1.240)	-4.832 (-1.459)	-4.259 (-2.681)***	-4.725 (-3.240)***
R-squared	0.038	0.089	---	0.969	---

[Specification tests]

	One-way model	Two-way model
F test (Pooled vs. Fixed effects)	3.97 [0.002]***	135.91 [0.000]***
F test (One-way vs. Two-way fixed effects)	---	141.51 [0.000]***
LM test (Pooled vs. Random effects)	7.89 [0.005]***	751.25 [0.000]***
Hausman test (Random Effects vs. Fixed effects)	-0.12 [1.000]	0.55 [0.459]

(3) Between the First and Second Crises: March 9, 1998 – June 8, 1998

[Regression results]

	Pooled OLS	One-way model		Two-way model	
		Fixed effects	Random effects	Fixed effects	Random effects
Constant	25.112 (34.742)***	---	26.371 (22.583)***	30.451 (29.270)***	27.997 (30.206)***
Stock price	-4.894 (-6.228)***	-23.961 (-7.374)***	-6.315 (-4.990)***	-10.923 (-9.310)***	-8.152 (-9.235)***
R-squared	0.098	0.186	---	0.943	---

[Specification tests]

	One-way model	Two-way model
F test (Pooled vs. Fixed effects)	7.68 [0.000]***	66.99 [0.000]***
F test (One-way vs. Two-way fixed effects)	---	66.08 [0.000]***
LM test (Pooled vs. Random effects)	3.27 [0.070]*	694.81 [0.000]***
Hausman test (Random Effects vs. Fixed effects)	0.07 [1.000]	12.85 [0.000]***

(4) During the Second Crisis: September 11, 1998 – December 9, 1998

[Regression results]

	Pooled OLS	One-way model		Two-way model	
		Fixed effects	Random effects	Fixed effects	Random effects
Constant	63.516 (46.328)***	---	41.631 (9.017)***	48.482 (22.628)***	49.958 (15.050)
Stock price	-9.864 (-6.472)***	47.666 (9.243)***	16.861 (3.520)***	8.496 (3.251)***	6.693 (2.771)***
R-squared	0.105	0.409	---	0.975	---

[Specification tests]

	One-way model	Two-way model
F test (Pooled vs. Fixed effects)	36.43 [0.000]***	154.75 [0.000]***
F test (One-way vs. Two-way fixed effects)	---	111.76 [0.000]***
LM test (Pooled vs. Random effects)	412.36 [0.000]***	863.09 [0.000]***
Hausman test (Random Effects vs. Fixed effects)	0.07 [1.000]	3.26 [0.071]*

(5) After the Crises: May 24, 1999 – August 17, 1999

[Regression results]

	Pooled OLS	One-way model		Two-way model	
		Fixed effects	Random effects	Fixed effects	Random effects
Constant	11.401 (23.583)***	---	12.171 (9.709)***	14.425 (6.496)***	23.431 (4.630)***
Stock price	-4.373 (-9.045)***	-20.717 (-3.457)*	-5.175 (-4.136)***	-7.525 (-3.253)***	-2.416 (-3.393)***
R-squared	0.186	0.270	---	0.895	---

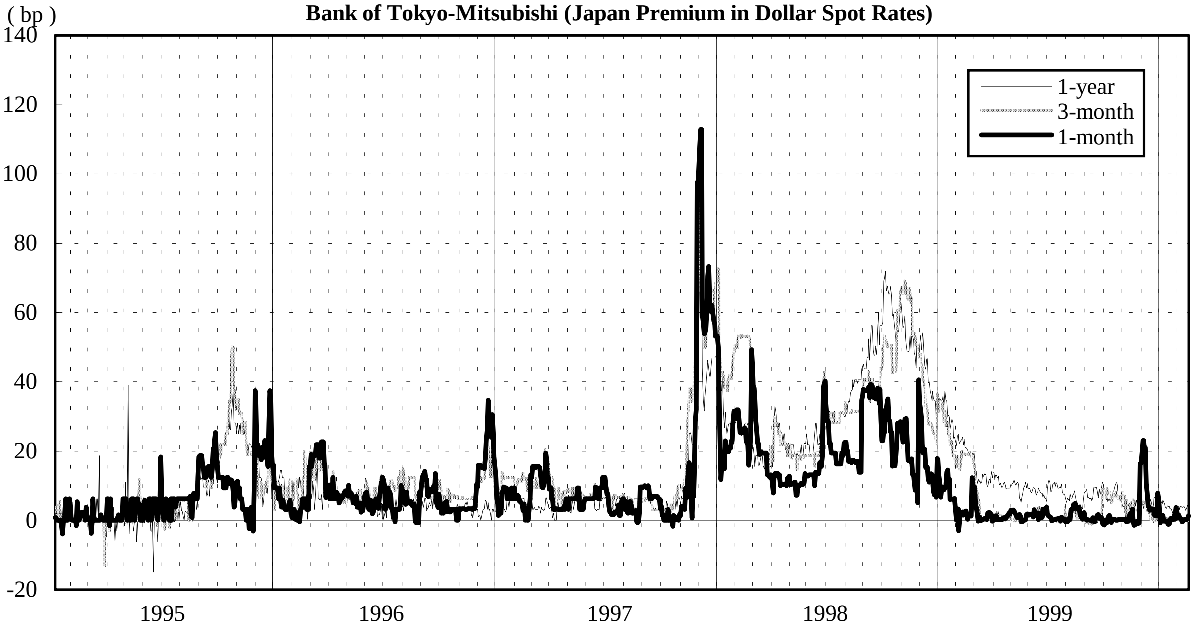
[Specification tests]

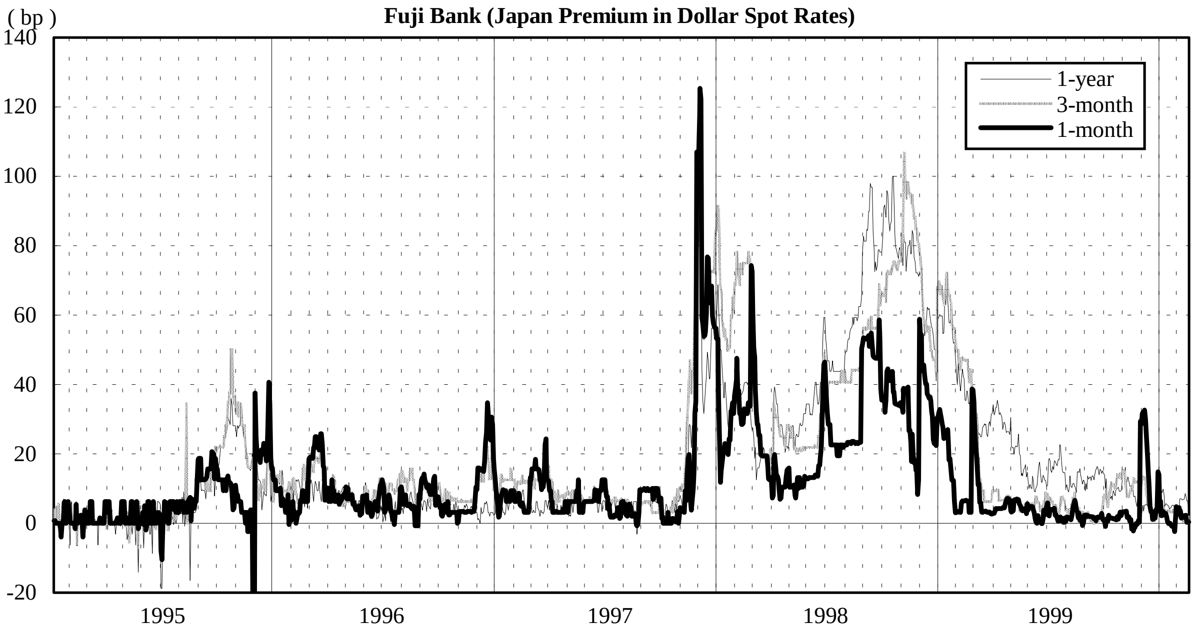
	One-way model	Two-way model
F test (Pooled vs. Fixed effects)	8.13 [0.000]	30.67 [0.000]***
F test (One-way vs. Two-way fixed effects)	---	29.78 [0.000]***
LM test (Pooled vs. Random effects)	42.49 [0.000]***	548.93 [0.000]***
Hausman test (Random Effects vs. Fixed effects)	0.00 [1.000]	1.36 [0.243]

Notes: 1. Figures in parentheses are standard errors that are adjusted for heteroskedasticity by White's (1980) procedure. ***, **, and * indicate that the estimated parameters are significant at 1%, 5%, and 10% levels, respectively.

2. Stock prices are adjusted for trading-day effects by the web-based program DECOMP.

Figure 1: The 'Japan premiums' in Dollar LIBORs

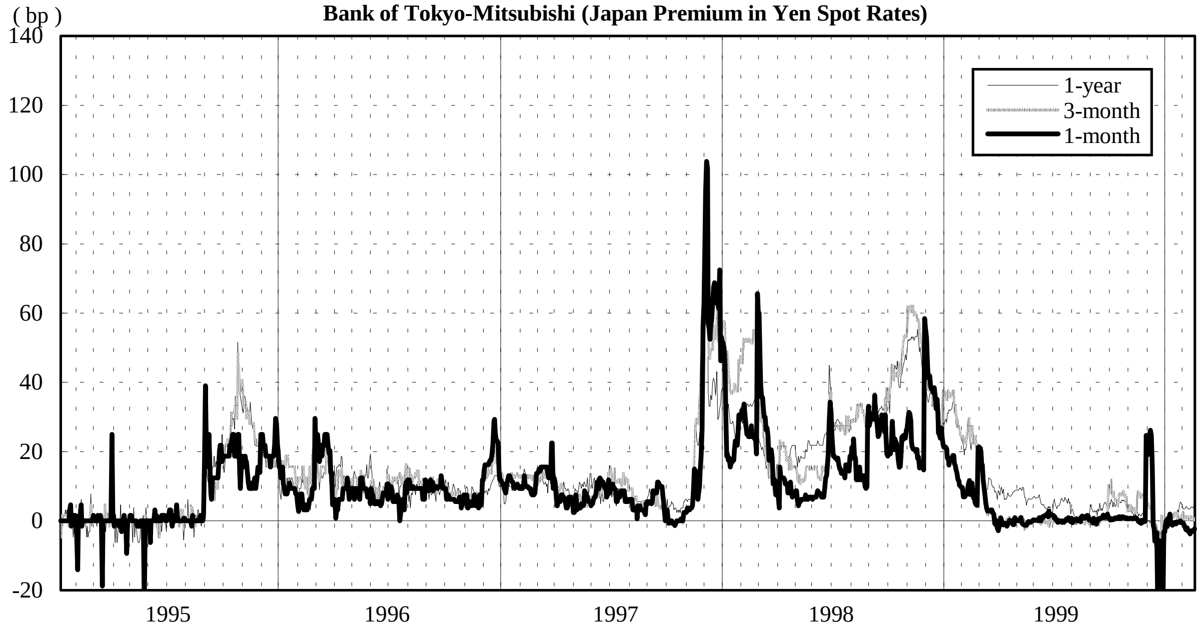


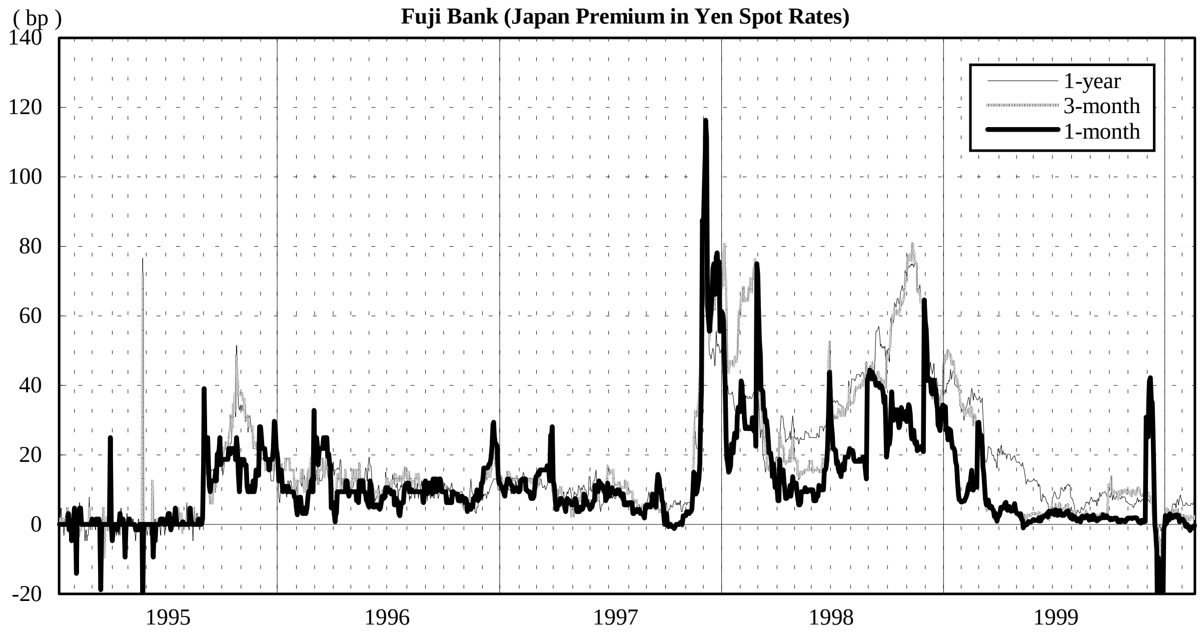


Source: Bloomberg

Note: The 'Japan premium' is calculated as the difference between LIBORs quoted by Japanese banks and the average of those quoted by Non-Japanese Banks.

Figure 2: The 'Japan premium' in Yen LIBORs

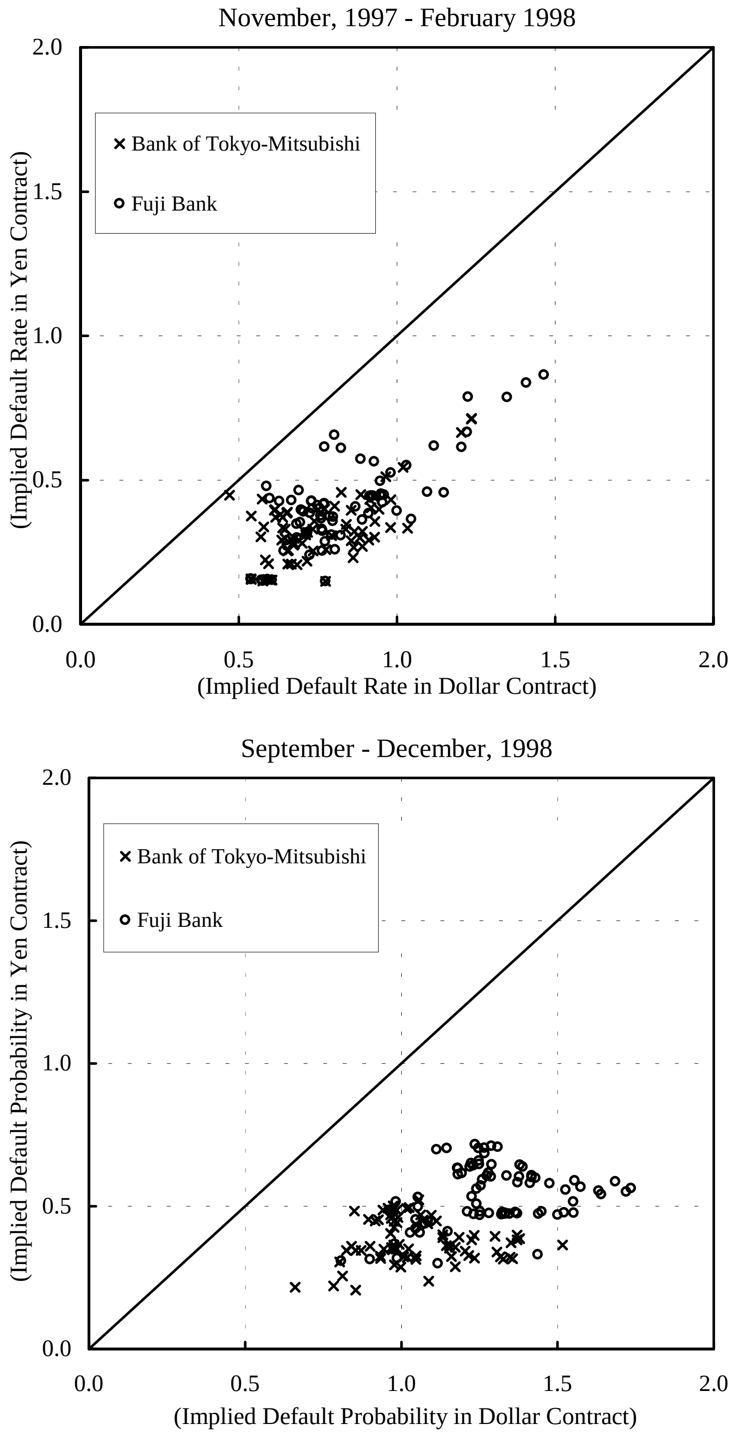




Source: Bloomberg

Note: 'Japan premium' is calculated as a difference between LIBORs quoted by Japanese banks and average of those quoted by Non-Japanese Banks.

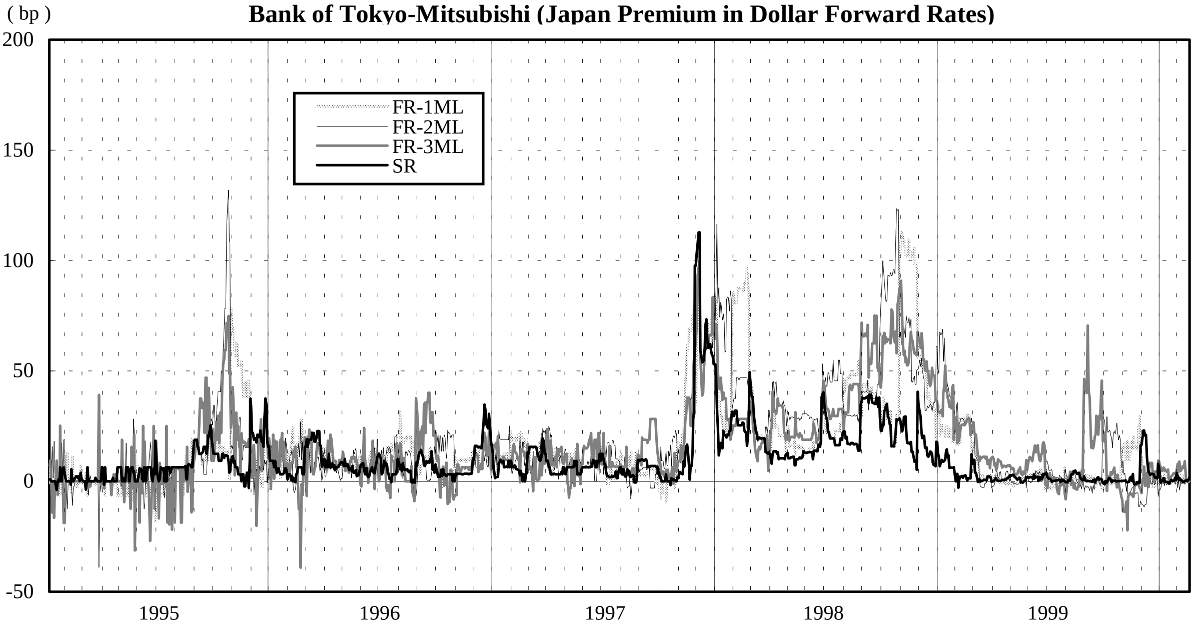
Figure 3: Implied Default Probability in LIBOR

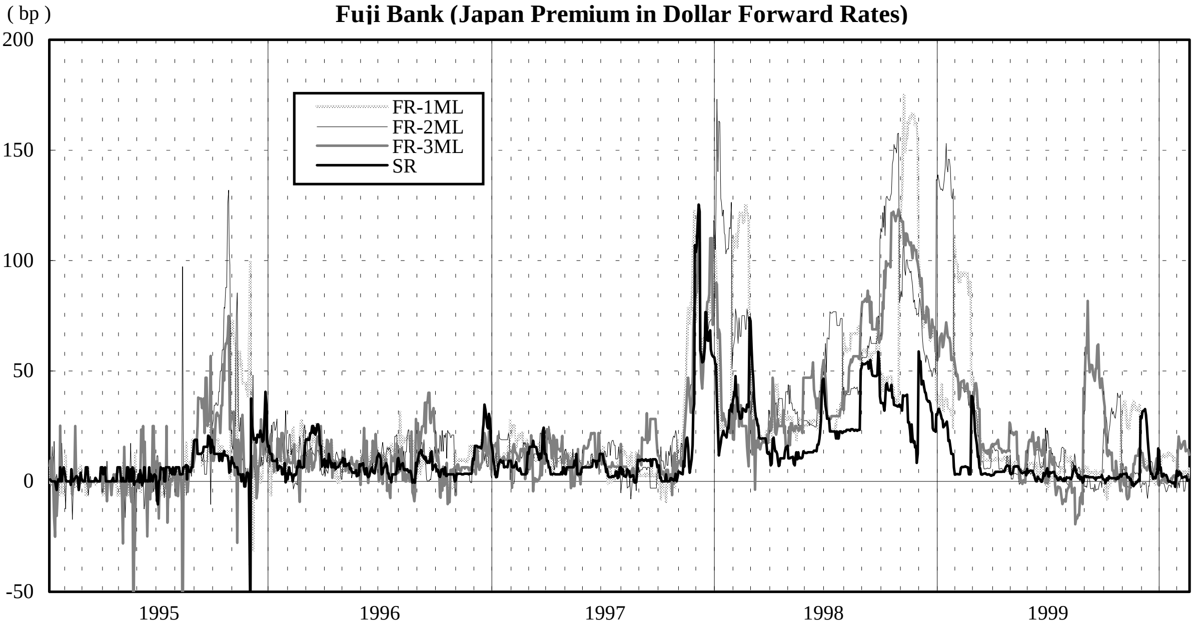


Source: Bloomberg.

Note: The implied default rate P is computed as $P = (R-r)/(1+R)$, where R is the one-year LIBOR quote for individual banks, and r is the one-year risk-free rate.

Figure 4: The 'Japan premium' in Implied Forward Rates of Dollar LIBOR

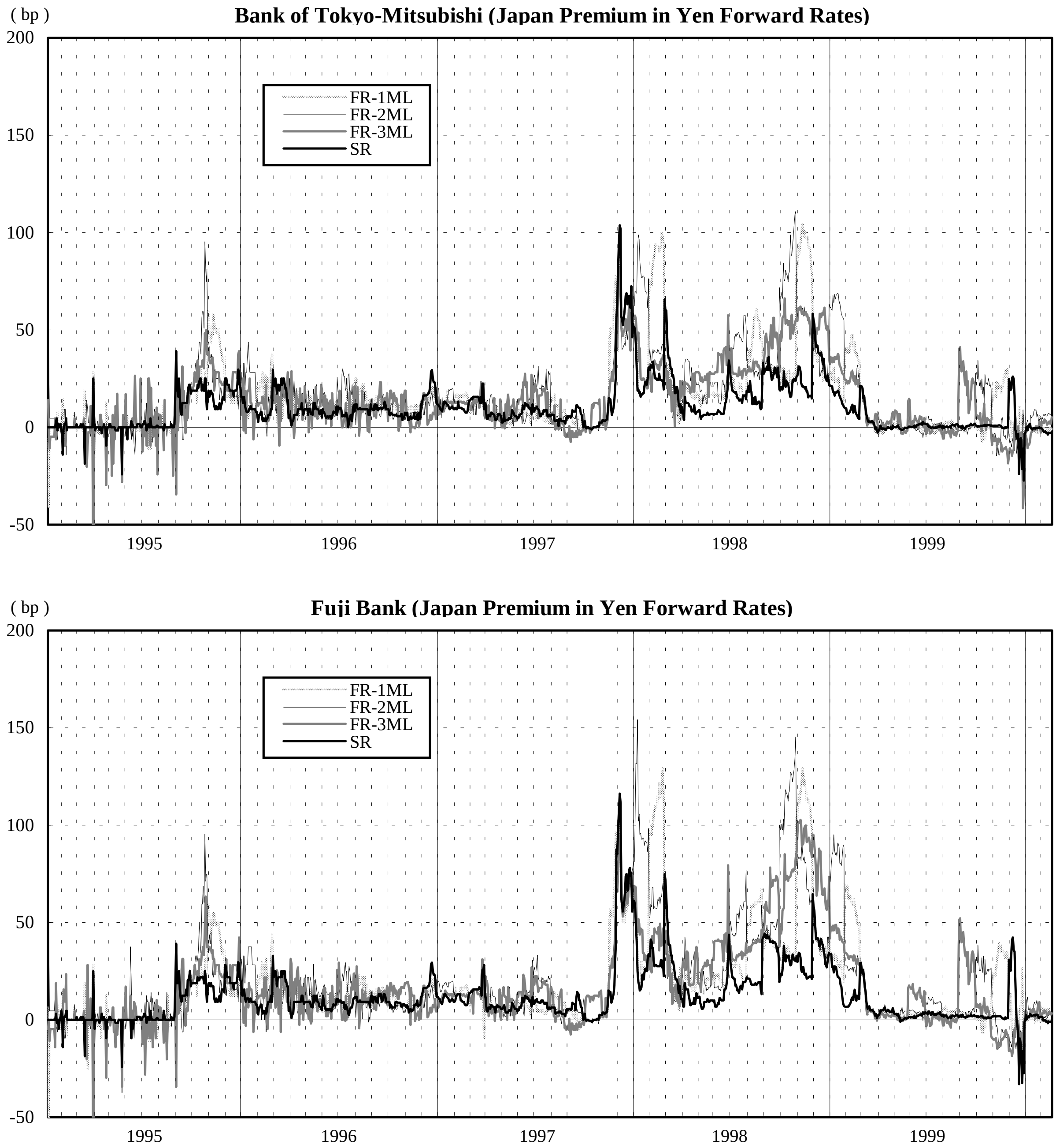




Source: Bloomberg

Note: The 'Japan premium' is calculated as the difference between LIBORs quoted by Japanese banks and the average of those quoted by Non-Japanese Banks.

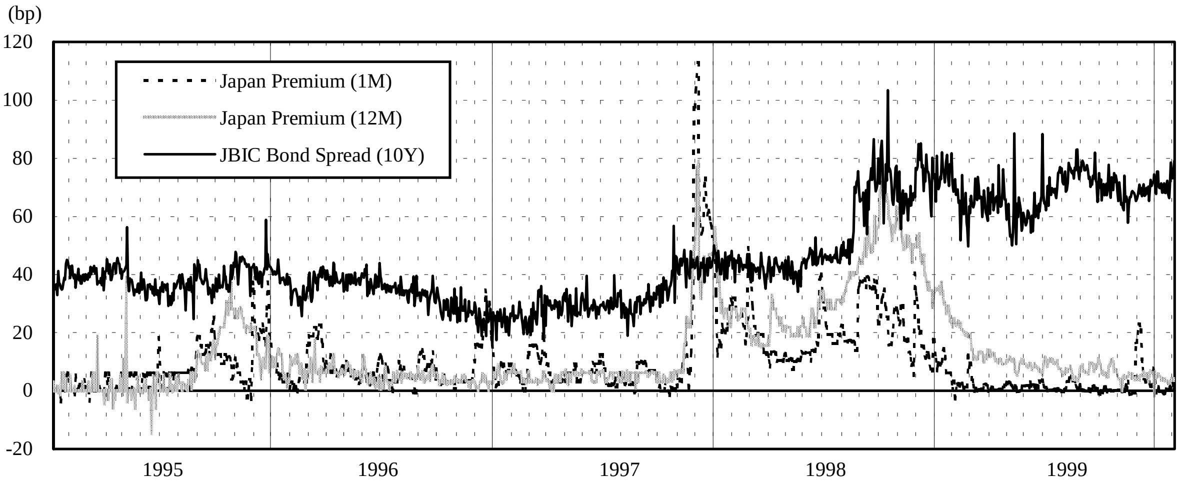
Figure 5: The 'Japan premium' in Implied Forward Rates of Yen LIBOR



Source: Bloomberg

Note: The 'Japan premium' is calculated as the difference between LIBORs quoted by Japanese banks and the average of those quoted by Non-Japanese Banks.

Figure 6: The 'Japan premium' and Sovereign Risk

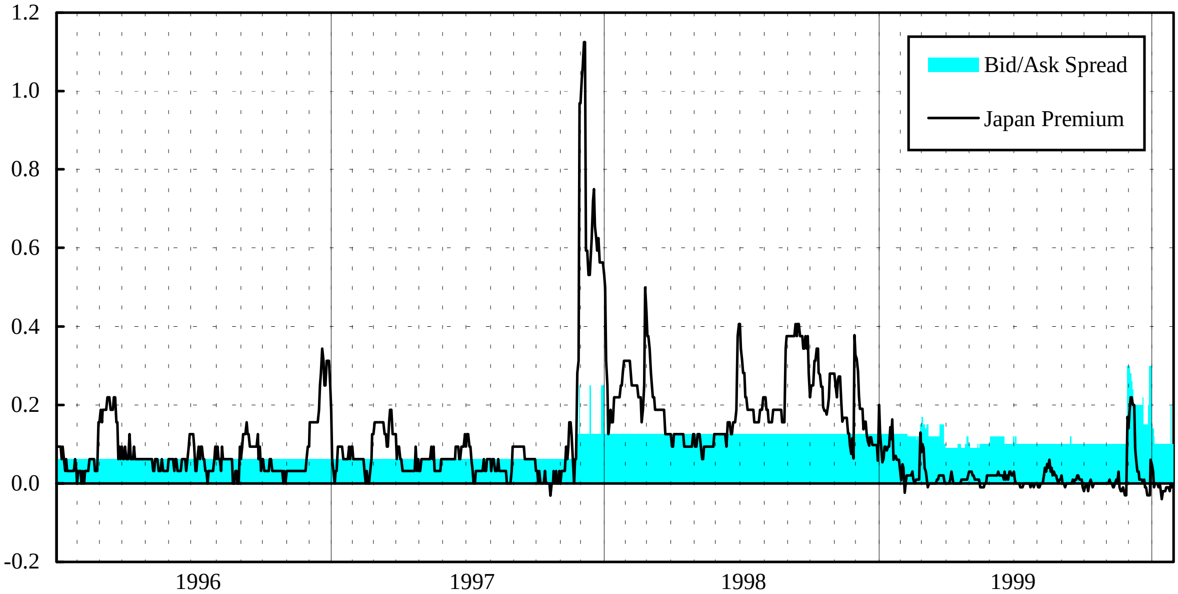


Source: Bloomberg

Note: 1. The 'Japan premium' is calculated as the difference between LIBORs quoted by the Bank of Tokyo-Mitsubishi and the average of those quoted by Non-Japanese Banks.

2. JBIC (Japan Bank of International Cooperation) Bond Spread is the spread against the US Treasury Bond yield (10-year). This spread indicates Japan's sovereign risk premium on a dollar basis.

Figure 7: Bid-Ask Spread for Inter-bank Market Rates



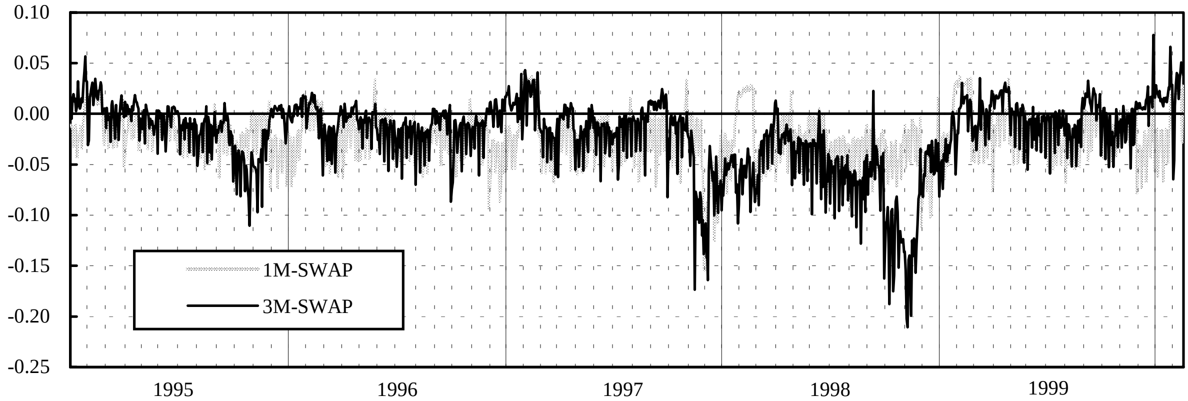
Source: Bloomberg

Notes: 1. Bid-ask spreads are calculated from 1-month Yen rates quoted by the Bank of Tokyo-Mitsubishi in the Japan Off-Shore Market.

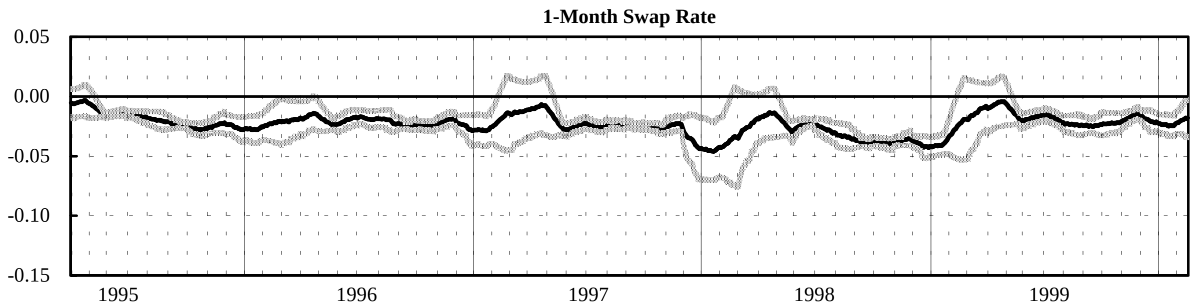
2. The 'Japan premium' is defined as the difference between 1-month Dollar LIBORs quoted by the Bank of Tokyo-Mitsubishi and those quoted by Barclays Bank.

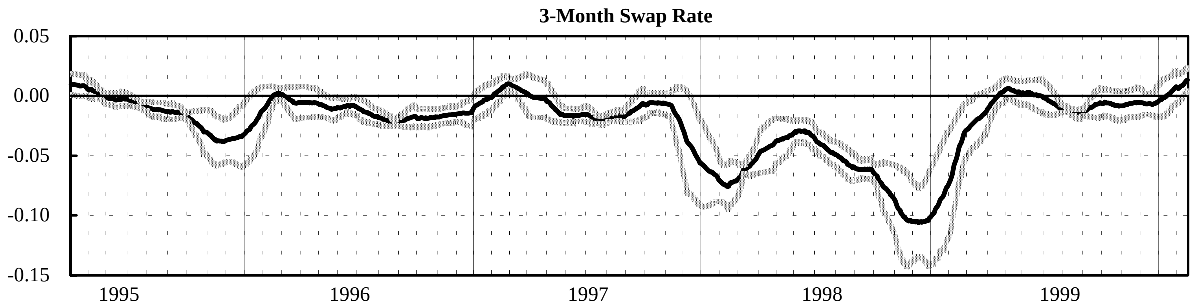
Figure 8: Break in Arbitrage Conditions for Dollar-Yen Swap Rates

(1) Difference between Market Rate and Theoretical Rate



(2) 95% Confidential Intervals





Sources: Bloomberg

Notes: 1. Market rates are mid prices between bet bid and ask prices. Theoretical rates are calculated from underlying asset prices.

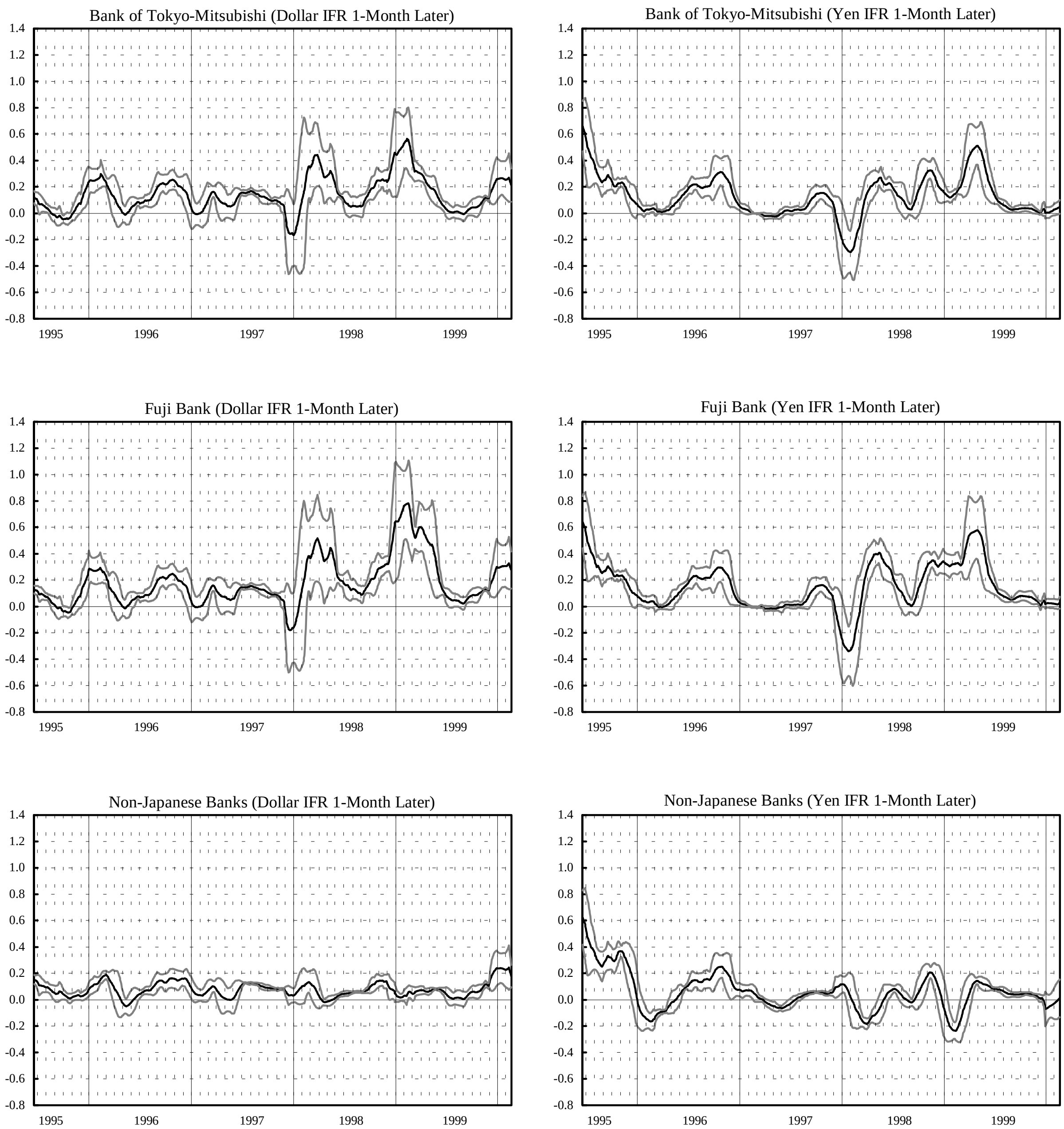
2. Rolling regressions on the following regression equation are conducted with the subsamples of 50 business days ending at each date on the horizontal axis.

$$TheoretcialRate_t - MarketRate_t = const + \varepsilon_t$$

3. Shaded lines indicate upper and lower bounds of 95% confidence interval (const+1.96*se) respectively. Standard errors are autocorrelation and heteroscedasticity robust estimators using Newy and West's (1987) procedure. Bandwidths are the twenty business days that approximately correspond to the number of business days in a month.

Figure 9: Forecasting Errors of Implied Foreword Rates for 1-Month Later

(Dollar LIBOR) (Yen LIBOR)



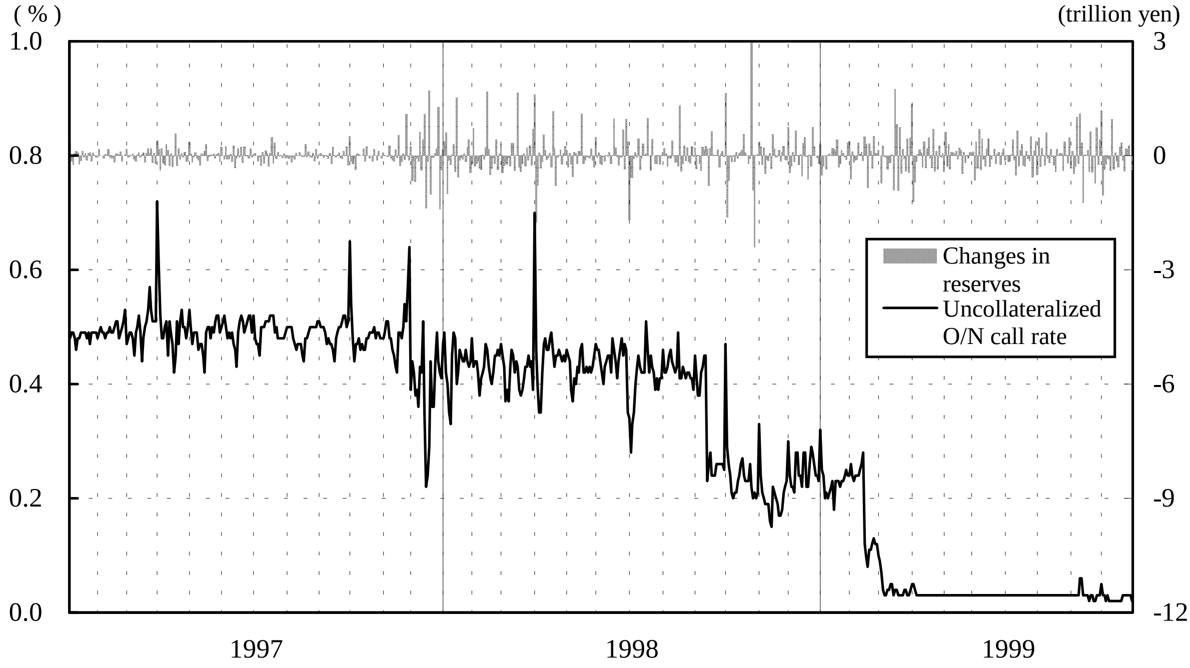
Source: Bloomberg

Note: 1. Rolling regressions on the following regression equation are conducted with the subsamples of 50 business days ending at each date on the horizontal axis.

$$IFR^{1M}_{-i} - SR^{1M}_{t} = const + \varepsilon_t$$

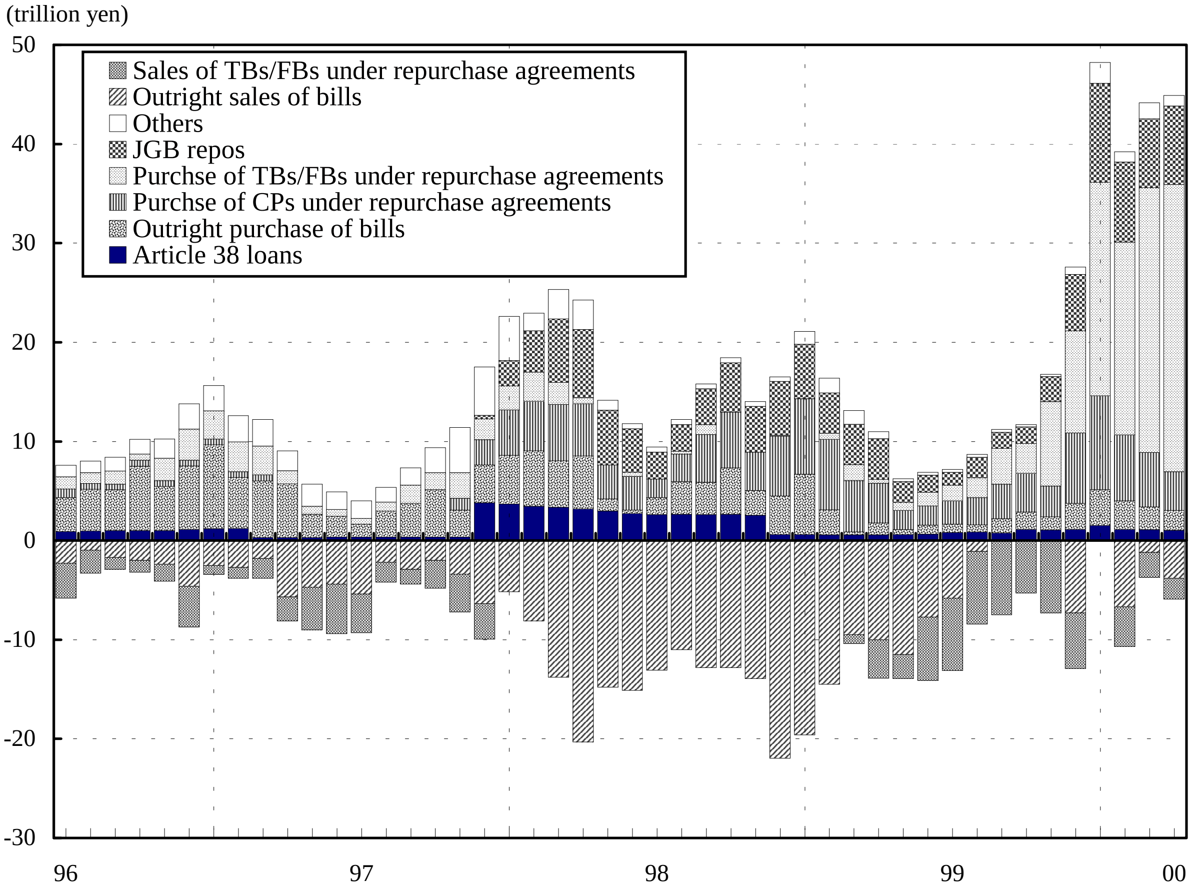
2. Shaded lines indicate the upper and lower bounds respectively of the 95% confidence interval (const+1.96*se). Standard errors are autocorrelation and heteroscedasticity robust estimators using Newy and West's (1987) procedure. Bandwidths are the twenty business days that approximately correspond to the number of business days in a month.

Figure 10: Call Rate and Monetary Base



Sources: Bank of Japan, *Financial and Economic Statistics Monthly*.

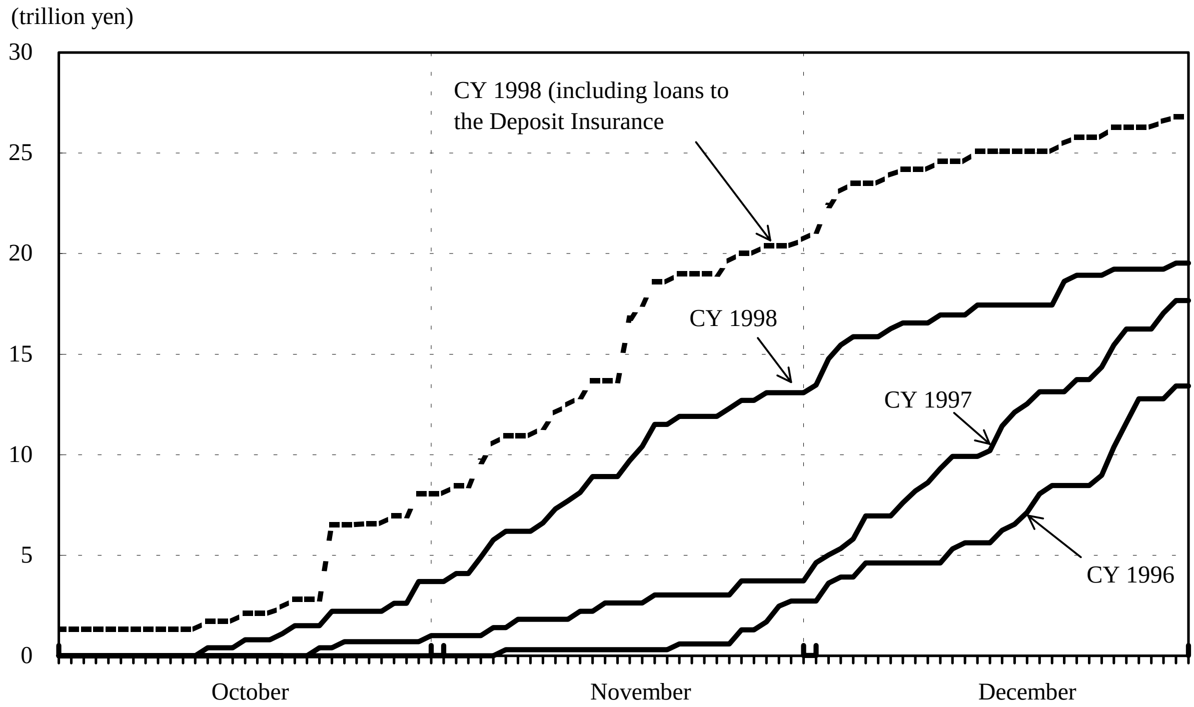
Figure 11: Bank of Japan's Money Market Operations (Outstanding)



Sources: Bank of Japan, *Financial and Economic Statistics Monthly*.

Note: Figures are amounts of outstanding at the end of month.

Figure 12: Provision of Yen Funds beyond the End of the Year



Sources: Bank of Japan, *Financial and Economic Statistics Monthly*.

Notes: The BOJ's operations to provide yen funds include loans except for the special loans provided under Article 38 of the Bank of Japan Law of 1997 (Article 25 of the former Bank of Japan Law), outright purchases of bills, purchases of TBs/FBs under repurchase agreement, JGB repo operations, purchases of JGB under repurchase agreements and purchases of CPs under repurchase agreements.