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Abstract

A major feature of recent monetary policy in Japan is heavy reliance on the so-called policy duration effect. Even though short-term interest rates decrease to virtually zero, a central bank can produce further easing by committing to maintaining zero interest rates for a considerable period of time in the future or providing an ample monetary base so as to lower short-term interest rates down to zero. These policy actions employ the policy commitment to compensate for the central bank's inability to lower the rate below zero by altering the expected future course of monetary policy actions. In practice, however, such easing effects have failed to be transmitted to the whole economy in Japan, since the transmission channel linking the financial and non-financial sectors has remained blocked. This paper analyzes the behavior of the yield curve and examines effectiveness and limitations of monetary policy commitment under zero interest rates. The policy duration effect was highly effective in stabilizing market expectations regarding the future path of short-term interest rates, thereby bringing longer-term interest rates down to flatten the yield curve. However, the policy duration effect failed to reverse deflationary expectations in the financial markets, since monetary policy alone could not reverse deflation, coupled with low economic growth.

Key words: Zero Interest Rate Policy; Quantitative Monetary Easing; Policy Duration Effects; Policy Commitment.

JEL classification: E31, E43, E52.

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I. Introduction

In this paper, we analyze the behavior of the yield curve and examine the effectiveness and limitations of monetary policy commitment under the recent deflationary economic environment in Japan.

Looking back at Japan's financial and economic development since the 1990s, the bursting of asset prices in the early 1990s was the beginning of a prolonged economic stagnation, characterized by several deep cyclical downturns with some modest short-lived economic recoveries. Under this economic environment, the Bank of Japan (BOJ) quickly reduced the official discount rate from 6 percent to 3.25 percent in about a year from the end of June 1991.[1]

The BOJ slowed the tempo of interest rate reductions in 1994, when it was faced with a record low official discount rate of 2.5 percent during the period when asset price bubbles were expanding in the late 1980s. As early as 1995, the BOJ still had little room for lowering short-term interest rates. The BOJ maintained the uncollateralized overnight call rate around 0.5 percent, while the Japanese economy recovered at a growth rate of more than 3 percent of GDP from 1995 to 1996. In the fall of 1997, the Japanese economy slipped into recession, triggered by financial system instability due to currency crises in South Asian economies and the successive failures of large financial institutions. Moreover, such financial system instability seemingly amplified the adverse effects of the bursting of the bubble.

The BOJ started lowering the overnight call rate gradually to 0.02 percent in February 1999, and in April Governor Hayami announced the BOJ's commitment to a zero interest rate "until the deflationary concerns were dispelled."[2] In August 2000, the BOJ terminated its zero interest rate policy and raised the overnight call rate to 0.25 percent, since the economy was showing clear signs of a continuing recovery.

However, in late 2000, the economy slowed again reflecting the adjustment of global information technology related investments and exports, and concern over deflation intensified. The BOJ lowered the policy interest rate to 0.15 percent in mid-February 2001, and then adopted "quantitative monetary easing" at the end of March. In this framework, the BOJ made a commitment to targeting the current account balance

1 See Okina and Shiratsuka (2002) for the details of the BOJ's policy response during this period.

2 See Table 1 for the details of the major policy changes by the BOJ.

at the BOJ until CPI inflation becomes stable at or above zero percent. As a result, overnight call rate initially declined to 0.01 percent, below 0.02 percent under the zero interest rate policy. It further declined to 0.001 percent in September 2001, due to the reduction of interest rate unit for call market transactions from 1/100 percent to 1/1000 percent.

Even though short term interest rates decline to virtually zero, a central bank can produce further easing effects by a policy commitment.[3] A central bank can influence market expectations by making an explicit commitment as to the duration it holds short-term interest rates at virtually zero. If it succeeds in credibly extending its commitment duration, it can reduce long-term interest rates. We call this mechanism "policy duration effect," following Fujiki and Shiratsuka (2002).

Recent BOJ's monetary policy is characterized by heavy reliance on the policy duration effect. As aforementioned, under the zero interest rate policy, the BOJ committed to zero interest rates until deflationary concerns were dispelled, while, under quantitative monetary easing, it commits to providing ample liquidity exceeding well over the required reserve until the CPI inflation becomes stably at or above zero percent. These policy actions employ the policy commitment to compensate for the central bank's inability to lower the rate below zero by altering the expected future course of monetary policy actions.

Fujiki and Shiratsuka (2002) examine the policy duration effect of the past zero interest rate policy, from February 1999 to August 2000, by focusing on the short end of the yield curve, of which maturity is shorter than one-year. They reveal that the zero interest policy produced a strong easing effect through two channels. First, it worked through expectations with respect to the future path of nominal interest rates that were captured by the shape of the yield curve. Second, it brought a significant liquidity effect amid the fragile state of the financial system and the financial markets, as witnessed by a significant decline in the term spreads of interest rates. However, such easing effects failed to be transmitted to the whole economy, since the transmission channels linking the financial and non-financial sectors remained blocked.

Kimura *et al.* (2002) apply Bayesian VAR analysis to examine the expansionary

[3] See Reifschneider and Williams (2000) and Jung, Teranishi, and Watanabe (2001) for detailed discussions on the policy commitment effect when a central bank faces zero boundary of nominal interest rates.

effect of the increase in the monetary base on the economy, which includes the policy duration effect and portfolio re-balancing effect. Their conclusion is that, though it is difficult to deny the possibility that the positive effect would increase and lead to a change in the portfolios of economic agents and ultimately stimulate economic activity, this possibility is highly uncertain and very small at the best.

In this paper, we analyze the behavior of the yield curve to examine the impact on market expectations regarding long-term interest rates under the past zero interest rate policy as well as the current quantitative monetary easing.[4] By doing so, we explore the effectiveness and limitations of monetary policy commitment. Since, as mentioned above, Kimura *et al*. (2002) show that the portfolio re-balancing effect of quantitative monetary easing is insignificant so far, we focus our attention on the policy duration effect by analyzing the behavior of the yield curve under the current quantitative monetary easing as well.

The policy duration effect was highly effective in stabilizing market expectations regarding the future path of short-term interest rates, thereby bringing longer-term interest rates down to flatten the yield curve. However, the policy duration effect failed to reverse deflationary expectations in the financial markets, since monetary policy alone could not resolve deflation, coupled with low economic growth. The expectation of prolonged deflation is observed most typically in lowered long-term interest rates. This indicates financial market expectations that deflation, coupled with low economic growth, will continue for years, rather than be quickly reversed.

This paper is organized as follows. Section II discusses the analytical framework to estimate and evaluate the policy duration effect, based on information contained in the yield curve. Section III presents data and estimation results. Section IV examines the effectiveness of the policy duration effect. Section V concludes the paper.

II. Analytical Framework

In this section, we discuss the basic framework for the analysis of the policy duration effect. We first define the policy duration effect, and then examine how to assess such

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[4] Assessment of the policy duration effect from observed interest rates can be based on two ways: one is a direct introduction of policy duration effect to a structural model for interest rate dynamics, and the other is analysis on the time-series movement of the shape of yield curve. This paper takes the latter approach, while Marumo *et al*. (2003) use the former.

an effect. We also explain the extended versions of Nelson and Siegel's (1987) model to estimate the shape of the yield curve over time.

A. The Policy Duration Effect

The policy duration effect essentially depends on how long the current abundant provision of funds (quantitative easing) will last in the future, rather than how abundant are the funds currently provided.

Based on the classification made by Clouse *et al.* (2000), a zero interest rate policy pursued by purchasing short-term financial instruments in open market operations would not be a stimulative way to increase the monetary base, because short-term financial instruments and the monetary base are essentially perfect substitutes for each other. However, under the BOJ's zero interest rate policy with the commitment to maintaining it for some considerable period of time in the future, the effect obtained via expectations regarding the future paths of the nominal interest rate, the inflation rate, and asset prices would be still useful. One might also expect that the credit channel would work simultaneously.

The BOJ's zero interest rate policy with the commitment until deflationary concerns are dispelled and quantitative easing with similar commitment later are both highly effective in stabilizing market expectations regarding the future path of short-term interest rates. Guiding the overnight rate to virtually zero for a considerable period of time in the future works as an anchor for medium-to-long term interest rates. As a result, the yield curve flattens and stabilizes at a very low level.

The above mechanism of a policy duration effect is underpinned by the expectations hypothesis regarding the term structure of interest rates. The pure expectations theory of the term structure of interest rates tells us that long-term interest rates today should reflect the future course of short-term interest rates.[5] For example, the one-year interest rate is determined by market expectations for overnight interest rates during the subsequent twelve-month period. Based on a more practical and general formula, long-term interest rates are the sum of market expectations regarding the future course of short-term interest rates and a term premium (based on risk caused

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[5] See Goodfriend (1998) regarding an excellent discussion on the use of the term structure of interest rates for monetary policy analysis.

by uncertainty or the preference of market participants). Premiums being constant, fluctuations of interest rates on term instruments reflect changes in expectations.[6]

B. The Extended Model of Nelson and Siegel (1987)

1. Specifications

We employ an extended version of Nelson and Siegel's (1987) model, proposed by Söderlind and Svensson (1997), as follows:[7]

$$r(m) = \beta_0 + \beta_1 \cdot \exp(-\frac{m}{\tau_1}) + \beta_2 \cdot (\frac{m}{\tau_1}) \cdot \exp(-\frac{m}{\tau_1}) + \beta_3 \cdot (\frac{m}{\tau_2}) \cdot \exp(-\frac{m}{\tau_2}), \qquad (1)$$

where β_0, β_1, β_2, β_3, τ_1 and τ_2 are parameters to be estimated from the data. We expect β_0, τ_1 and τ_2 to be positive. This model has simple, parsimonious functional forms, but flexible enough to capture the general property of the yield curve for monetary policy purposes.

The instantaneous forward rate (IFR) curve, shown in equation (1), includes four terms. The first term is a constant β_0. The second one is an exponential function β_1*exp($-m/\tau_1$). β_1 always takes a negative value in our estimation periods, producing an upward-trending shape for the IFR curve. A large (small) value of τ_1 means that this exponential effect decays more slowly (quickly). The third one is β_2*(m/τ_1)*exp($-m/\tau_1$), producing U-shape (hump shape) when β_2 takes a negative (positive) value. β_2 is typically insignificantly different from zero under the zero interest rate policy as well as the quantitative easing.[8] β_2 is, however, significantly

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6 Given the possibility of time-varying risk premium, we should be careful in interpreting time-series movements of estimates.

7 The extended Nelson-Siegel model, shown in equation (1), add the third term to the original one, thus allowing up to two hump- or U-shapes in IFR curve, while the original one has only one hump- or U-shape.

8 When β_2 is zero, the extended Nelson-Siegel model converges to the generalized Nelson-Siegel model, used in Fujiki and Shiratsuka (2001), as follows:

$$r(m) = \beta_0 + \beta_1 \cdot \exp(-\frac{m}{\tau_1}) + \beta_3 \cdot (\frac{m}{\tau_2}) \cdot \exp(-\frac{m}{\tau_2}).$$

However, we apply the extended Nelson-Siegel model for all the observations in the sample period, because it is difficult to find consistent criteria to select a better model among the two, given the small difference in likelihood. Estimated parameters are generally same regardless of specification, except for standard errors of τ_1 is larger in the extended Nelson-Siegel model when β_2 is equal to or closed to zero.

lower than zero when the IFR curve manifests a complex shape, such as an initial stage of zero interest rate policy, and the end of a fiscal year or end of the reserve maintenance period when the overnight rate temporarily jumps. The fourth one produces U-shape, since β_3 always takes a negative value in our estimation periods, creating a U-shape (a hump-shape when β_3 is positive). τ_2 controls the speed of convergence of the fourth term, as τ_1 for the second and third term.

The specification for the spot rate, denoted $R(m)$, can in turn be derived by integrating the equation (1) from zero to m and dividing by m. That is

$$R(m) = \frac{1}{m}\int_{s=0}^{m} r(s)ds\,, \tag{2}$$

and the specific functional form employed in the estimation is as follows:

$$\begin{aligned} R(m) &= \beta_0 + \beta_1 \cdot (\frac{\tau_1}{m}) \cdot \left(1 - \exp(-\frac{m}{\tau_1})\right) \\ &+ \beta_2 \cdot \left[(\frac{\tau_1}{m}) \cdot \left(1 - \exp(-\frac{m}{\tau_1})\right) - \exp(-\frac{m}{\tau_1}) \right] \\ &+ \beta_3 \cdot \left[(\frac{\tau_2}{m}) \cdot \left(1 - \exp(-\frac{m}{\tau_2})\right) - \exp(-\frac{m}{\tau_2}) \right]. \end{aligned} \tag{3}$$

Important features of equations (1) and (3) are that the limits of forward and spot rates when maturity approaches zero and infinity, respectively, are equal to $\beta_0+\beta_1$ and β_0. In estimation, we exploit these features to avoid the very short end of the IFR curve becoming negative, by restricting that the overnight uncollateralized call rate is equal to $\beta_0+\beta_1$.

2. An illustration of the contributions of each components in the Nelson-Siegel Model

We next provide an intuitive explanation of the estimates for the extended Nelson-Siegel model.

Figure 1 plots a hypothetical IFR curves for the extended version of the Nelson-Siegel model with the parameters as follows: $\beta_0 = 2.8$, $\beta_1 = -2.8$, $\beta_2 = 0.0$, $\beta_3 = -6.0$, $\tau_1 = 0.3$, $\tau_2 = 1.0$ for the upper panel, and $\beta_0 = 2.8$, $\beta_1 = -2.3$, $\beta_2 = -1.0$, $\beta_3 = -6.0$, $\tau_1 = 0.3$, $\tau_2 = 1.0$ for the lower panel. The parameters are common except for β_1 and β_2. These parameters are chosen, because they represent typical shapes of the IFR curve under the zero interest rate policy as well as the quantitative monetary easing. The upper panel illustrates the most typical shape of the IFR curve, while the lower panel corresponds to the situation where the overnight rate temporarily jumps at the end of the calendar year, the fiscal year, or the reserve maintenance period.[9]

This figure also shows the contributions of each term, and the first and fourth terms are common in these two panels, since the same parameters except for β_1 and β_2 are used. The first term, β_0, is constant over the whole range of time-to-settlement. The second term $\beta_1 * \exp(-m/\tau_1)$ is an exponential function, shaping an upward trend in the short end of the IFR curve when β_1 is negative. This impact decays gradually (quickly) as τ_1 becomes larger (smaller). The third term in the lower panel, $\beta_2 * (-m/\tau_1) * \exp(-m/\tau_1)$, creates a U-shape in the short-term since β_2 is negative.

The fourth term, $\beta_3 * (-m/\tau_2) * \exp(-m/\tau_2)$, also adds a U-shape since β_3 is negative (a hump shape when positive). This term allows a non-monotonic increase in the IFR curve, since this U-shape decays slower than that of the third term, because τ_2 is larger than τ_1. A large (small) value of τ_2 means that the effects decay more slowly (quickly), and the IFR converges to the long-term forward rate more slowly (quickly).

Focusing on the fourth term, since β_3 is negative, this term creates a U-shape, taking the minimum at τ_2 and the inflection point at $2*\tau_2$. Moreover, the point of $2*\tau_2$ approximately corresponds to the inflection point for the IFR curve as a whole, since the second and the fourth terms almost converge to zero at the point of $2*\tau_2$. Therefore, at this point, $r'(m)$ is approximately locally maximized and $r''(m)$ is approximately equal to zero.

C. Indicators for the Policy Duration Effect

Based on estimates for the extended Nelson-Siegel model, we next compute indicators for the policy duration effect, which captures market expectations on the duration of the policy commitment and the flatness of the yield curve.

Figure 2 illustrates the indicators by using the same parameter values as the top panel of Figure 1. In this figure, the upper and lower thin curving lines indicate the IFR curve, $r(m)$, and the spot rate curve, $R(m)$, respectively. $r(m)$ starts from zero at

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[9] $r(0)$, which is equal to $\beta_0+\beta_1$, is supposed to be zero under the zero interest rate policy as well as the quantitative monetary easing, as shown in the upper panel, while $r(0)$ in the lower panel, which is also equal to $\beta_0+\beta_1$, is significantly higher than zero. Since β_0 is equal to the limits of forward and spot rates when maturity approaches infinity, this parameter is common for both panels. Therefore, the absolute value of β_1 must take a different value from that of β_0 when overnight rate temporarily jumps..

maturity zero, manifests a two-stage upward trend from the short end to mid-range, and finally converges to a long-term forward rate of β_0, shown as a dashed horizontal line close to the top. This figure indicates the following four points regarding the policy duration effect:

(i) The duration of the flattened shape of $r(m)$ before its second stage increase reflects the market expectations of how long $r(m)$ stays close to zero, and thus how long the BOJ will commit to a zero interest rate.

(ii) The flatness of $r(m)$ before its second stage increase indicates the confidence of market participants regarding to what extent $r(m)$ remains low, and thus how strong the BOJ's commitment to a zero interest rate.[10]

(iii) The sharpness of $r(m)$ in its second stage increase shows the market expectations as to how fast the economy will escape from the zero interest rate situation, and thus how fast $r(m)$ converges to the long-tem forward rate, described as β_0.

(iv) β_0 is the long-term forward rate, and is considered as a proxy for the summation of expected inflation and expected economic growth, or expected nominal economic growth. This is deemed to reflect the market expectations regarding the future course of the economy.[11]

Based on the above observations, we define four indicators for the policy duration effect. First, we define the policy duration, denoted by *PD*, at the point of τ_2, where $r(m)$ becomes increasingly upward-trending in the second stage increase, typically at the year-to-settlement of around one year or more. As aforementioned, the fourth term in the right hand side of equation (1) takes minimum value at this point, and thus all the downward factors are exhausted at this point, since τ_2 always take larger value than τ_1. In the figure, *PD* is one year, indicated by the first dashed vertical line to the left.[12]

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[10] As shown by Fujiki and Shiratsuka (2002), $r(m)$ is also affected by the liquidity concerns of financial institutions, especially at the time of large liquidity events, such as the Y2K problem and introduction of the real time gross settlement system.

[11] In examining the time-series movements of the long-term forward rate, we should be careful for possible effects of demand-supply conditions in financial markets with long-term maturity.

[12] An alternative definition of *PD* is possible, depending on how to define the end of the flatted zone before the second stage increase. For example, another possible definition is the point where the second derivative of $r(m)$, or acceleration of the speed of increase in $r(m)$, is locally maximized. Although the estimates based on our definition is a little larger than those based on the alternative definition, these two

Second, we use the estimated spot rate at PD, $R(PD)$, as a measure of the market confidence in the BOJ's policy commitment to a zero interest rate. This is because, as shown in equation (2), $R(PD)$ is equivalent to the lower area of the IFR curve from zero to PD. That is,

$$R(PD) = \frac{1}{PD} \int_{s=0}^{PD} r(s) ds \,. \tag{4}$$

In other words, $R(PD)$ is the averaged IFR between zero to PD. Thus, a smaller $R(PD)$ implies that financial market participants expect a lower future path of short-term interest rates, and are more confident about the BOJ's commitment to zero interest rates. In the figure, $R(PD)$ is approximately equal to 0.4 percent, shown as a dashed horizontal line close to the bottom. It is equivalent to the shaded area, or the integral of the IFR curve from zero to PD, divided by PD.

Third, we employ a slope of $r(m)$ at the inflection point as a proxy for the flatness of the whole shape of the curve. Due to the definition of the inflection point, this is the maximum grade of $r(m)$ in the second stage increase. $r(m)$ then gradually converges to the long-term forward rate, given by β_0. Let us denote this slope SL, and, given that the inflection point approximately corresponds to $2^*\tau_2$ in our specification, the slope at this point is:

$$SL = \arctan(r'(2 * \tau_2)) \,. \tag{5}$$

In the figure, $2^*\tau_2$ is 2.0 years, depicted by the second dashed vertical line from the left. SL is approximately 39.5 degree.

Fourth, we use β_0, which corresponds to a long-term forward rate, or LFR, as a proxy for the summation of expected inflation and expected economic growth, or expected nominal economic growth. More precisely, steady-state nominal interest rate i^* is equal to the sum of the steady-sate real interest rate r^* and the steady-state rate of inflation π^* by Fisher's equation, and thus LFR can be written as

$$LFR = i^* + \rho = r^* + \pi^* + \rho \,, \tag{6}$$

where ρ is a risk premium. This is deemed to reflect the market expectations on performance of the economy over the long term.

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estimates show very similar movements over time, observed as very high coefficient of correlation at 0.96. Moreover, our definition has an advantage that we can easily compute standard errors for PD as well as $R(PD)$ based on the closed form solution for PD.

It should be noted that, among four indicators for the policy duration effect, the first two indicators show initial impacts of the policy commitment to zero interest rates, while the other two indicators show market assessments on those impacts in the medium- to long-term.

D. Assessment of the Policy Duration Effect

We assess the policy duration effect, based on the estimation results for the instantaneous forward rate (IFR) curve over time. To this end, we examine relationship between the flatness of the IFR curve in the short end, and the steepness of the IFR curve in the mid-range as well as the level of a long-term forward rate.

In this context, we regard the changes in *PD* and *R*(*PD*) before and after the policy events as a policy surprise. This is because the flatness of the IFR curve in the short end reflects market assessment on the strength of the policy commitment. In other words, the shape of IFR curve in the short end shortly before the policy event reflects market expectations about the impacts of possible policy change at that event.

Similarly, we regard the changes in *SL* and *LFR* as policy impacts on the market expectations regarding the future course of short-term interest rates. The steepness of the IFR curve in the mid-range shows the market expectations as to how fast the economy escape from the zero interest rate situation, while the long-term forward rate is a proxy for the summation of expected inflation and expected economic growth, or expected nominal economic growth.

If the policy duration effect is strong enough to alter market expectations regarding the future course of the economy toward positive direction, the slope of the IFR curve in the mid-range as well as the long-term forward rate are expected to increase. In addition, such positive expectations in turn shorten the expected duration of the policy commitment to a zero rate or quantitative monetary easing. On the contrary, if the policy duration effect is not sufficiently effective and expectations of deflation and low economic growth remains, the slope of the IFR curve in the mid-range and the long-term forward rate are unlikely to increase.

III. Data and Estimation Results

In this section, we present data used in estimating the IFR curve over time and the estimated results of the IFR curve. In addition, we also illustrate the typical shape of

IFR curves around the period of policy changes, and examine their implications for the policy duration effect.

A. Data

We use data for euro yen Tokyo interbank offered rates (TIBOR) as short-term interest rates, ranging from one- to 12-month contracts, and yen swap rates as medium- to long-term interest rates from two- to 12-year contracts. As aforementioned, we also use overnight uncollateralized call rate to impose a restriction that the overnight call rate is equal to $\beta_0+\beta_1$. The sample period is from March 2, 1998 to February 28, 2003 for every business day.

As pointed out in Shigemi *et al*. (2000) and Fukuta, Saito, and Takagi (2002), the pricing of Japanese government bonds (hereafter JGB) crucially depends on their convenience, reflecting a difference in the characteristics of each issue, such as outstanding volume and coupon rate, as well as market liquidity. In particular, the pricing of JGB in 1998-2000 was highly distorted due to various problems with regard to market liquidity, including the Y2K problem. Therefore, it is deemed difficult to extract a unique yield curve as a benchmark from the market rates of JGBs, given the possible credit premium and other disturbing factors, such as macro-hedge accounting, on euro yen TIBORs and swap rates.

B. Estimated Results for the Nelson-Siegel Model

Figure 3 summarizes the estimates of parameters β_0, β_1, β_2, β_3, τ_1, and τ_2 from the top panel to the bottom.[13] In each panel, a solid line shows the estimated parameters, and shaded lines show the upper and lower bounds of each parameter, created by adding and subtracting two times the standard errors of the estimated coefficient.

The magnitudes and signs of the estimated parameters are consistent with our presumptions about the typical shape of the IFR curve since 1998. For example, β_0 and β_1 typically range from 2 to 3, and –3 to –2, respectively, except for the periods of the JGB market boom in the fall of 1998 and in January 2003. β_2 is insignificantly different from zero, except for the period when the IFR curve manifests a complex shape, such as an initial stage of zero interest rate policy, and the end of a fiscal year or

[13] Our estimations use the CML procedure in GAUSS 3.5.

end of the reserve maintenance period when the overnight rate temporarily jumps. β_3 always takes a negative value, and is stable, ranging from −6.0 to −3.5, except in 1999 when it often takes the value less than –7.0. τ_1 and τ_2 always take positive values, and they are stable until 2000 and gradually rise from the beginning of 2001.

C. Changes in the Shape of Forward Rate Curve over Time

Next, based on the above estimation results, we illustrate the changes in the shape of the IFR curves over time, and examine their implications for the policy duration effect.

1. Period of the zero interest rate policy

Figure 4 illustrates typical shapes of the IFR curve during the period of the zero interest rate policy from February 1999 to August 2000: the top panel for the period around the introduction of the zero interest rate policy, and the lower panel for the period around the termination. The horizontal axis in the figure shows the year-to-settlement, and the vertical axis shows the level of the IFR curve in percentage terms.

In the top panel of Figure 4, soon after the introduction of the zero interest rate policy, the IFR curve declined in the short-end, less than one year (shaded line: January 1999 → bold dashed line: March 1999). This reflects the subdued concerns over the instability of financial markets due to the joint effects of the zero interest rate policy and the re-capitalization of major banks. After Governor Hayami's announcement at a press conference on April 13, 1999 to commit to the zero interest rate, the IFR curve shifted further downward, especially in the range longer than one year (bold dashed line: March 1999 → thin dashed line: May 1999).

Later, the IFR curve in the range longer than one year reversed upward from May to July 1999 (thin dashed line: May 1999 → solid line: July 1999), which is partly attributable to the recovery in public sentiment, evidenced by the increase in stock prices. This suggests that the policy duration effect on top of mild recovery was consistent with improving the market forecast of business conditions, thereby pushing up the long-term forward rate.

The bottom panel shows that, from April to early July, 2000, the IFR curve moved up in the short end, while the curve exceeding one year remained almost unchanged (shaded line: April 2000 → bold dashed line: early July 2000), indicating the increased expectations of termination of the zero interest rate policy. After the termination of the zero interest rate policy, the IFR curve shifted further upward in the short end (bold dashed line: early July 2000 → thin dashed line: September 2000). Though this is partly attributable to the increased liquidity demand stemming from growing cautiousness over the introduction of the real time gross settlement (RTGS) system at the beginning of 2001, the increase in the long-term forward rate suggests the further strengthened prospect for economic recovery among market participants.

Based on the above observations, the termination of the zero interest rate policy was not necessarily inconsistent with the market expectations at that time. Moreover, it is difficult to say that the termination hampered the sentiment for economic recovery, thus triggering the economic downturn. If so, in response to the termination of the zero interest rate policy, the IFR curve should have shifted downward in the long end.

2. Period of the quantitative monetary easing

Figure 5 illustrates the typical IFR curve after the launch of the quantitative monetary easing: the top panel shows the period around the launch of the quantitative monetary easing, the middle panel the period of raising the target of the current account balance at the BOJ from 5 to 10-15 trillion yen, and the bottom panel the period of further raising the target to 15-20 trillion yen.

In the top panel, the IFR curve started shifting downward from January to early March, 2001 (shaded line: January 2001 → bold dashed line: early March 2001) prior to the launch of the quantitative monetary easing. This downward shift was induced by two factors. First, the downward shift in the short end, less than one year, occurred in response to the policy changes toward easing: the reduction of the official discount rate on February 9 as well as the reduction of both the official discount rate and the overnight call targeted rate on February 28. Second, the decline in the long-term forward rate is deemed as reflecting the downward revision of economic growth forecasts.

After the launch of the quantitative monetary easing on March 19, 2001, the IFR curve became twisted (bold dashed line: early March 2001 → thin dashed line: end April 2001): decline in the short end, steepening in the two- to seven-year range, and an increase in the long-term forward rate in the long end. This change in the IFR curve suggests that the policy duration effect of the quantitative monetary easing at the initial stage contributed to reversing the depressed sentiment in the financial markets before its introduction.

The middle panel shows that the IFR curve was hardly influenced by the increase in the target level of the current account balance at the BOJ from over 6 trillion yen to 10-15 trillion yen on December 19, 2001. This indicates that the strengthening of the quantitative monetary easing was not perceived as stimulative enough to mitigate the depressed sentiment in the financial markets, and influence the economy at this stage.

Furthermore, the bottom panel clearly shows that the IFR curve shifted continuously downward, as the target level of the current account balance was raised. The lowered long-term forward rate implies that market participants forecast that the current deflation would persist for years even under the quantitative monetary easing, rather than be reversed quickly. Thus, it is hardly to deny that the quantitative monetary easing so far has failed to reverse the market expectations of prolonged deflation.

IV. Assessment of the Policy Duration Effect

In this section, we compute indicators for the policy duration effect, based on the estimated results in the previous section, and assess the policy duration effect under the zero interest rate policy as well as quantitative monetary easing. In so doing, we examine the longer-term movements of various indicators for the policy duration effect, and take case study analysis of short-term impacts of policy changes on various indicators for the policy duration effect.

A. Computed Indicators for the Policy Duration Effect

Figure 6 displays the computed results of the aforementioned indicators over time: the top panel for the policy duration ($PD = \tau_2$), the second top panel for the estimated spot rate at PD ($R(PD)$), the second bottom panel for the slope of the IFR curve at the inflection point ($SL = \arctan(r'(2*\tau_2))$), and the bottom panel for the long-term forward rate ($LFR = \beta_0$). The figure also shows the confidence interval for each indicator by shaded line, by adding and subtracting two times standard errors of each indicator.[14]

The top panel of the figure shows that PD has three upward trend phases. The first phase is the period soon after the launch of the zero interest rate policy, and PD increased from around one in early February 1999 to around 1.4 in mid-April 1999. However, PD leveled off after Governor Hayami's announcement of the policy

[14] We apply the delta method to compute standard errors for $R(PD)$ and SL.

commitment on April 13, 1999, and then gradually declined toward the end of 1999.

The second phase is after the turn of the year 2001, when *PD* started rising gradually again, reflecting the growing expectation of a policy reversal toward monetary easing. When the quantitative monetary easing began, *PD* had already reached the same level as the peak soon after the launch of the zero interest rate policy. Thereafter, it continued rising until the end of June, reaching a peak of 2.03.

The third phase is the period since April 2002. *PD* continued rising again, though its tempo was relatively slow compared with the previous two upward-sloping phases. During this period, financial market participants seem to build up their expectations that deflation continues for years, rather than it is quickly reversed.

The second top panel plots *R*(*PD*) and shows two major declines: one is February to March 1999 and the other is early 2001. The first decline occurred soon after the launch of the zero interest rate policy. *R*(*PD*) declined about 40 basis points in a month, from 0.700 percent on February 10 to 0.313 on March 17. After leveling off from mid-March to April, it declined further to 0.180 percent toward the end of May, as the commitment effect of the zero interest rate policy pervaded through financial markets, while it reverted to the mid-March level in summer. From the spring to summer of 2000, *R*(*PD*) increased steadily, reflecting growing market expectations of an early termination of the zero interest rate policy amid a recovery in business conditions.

After the turn of the year 2001, the second decline occurred shortly before the launch of the quantitative monetary easing, not after. This suggests that the market started incorporating the policy reversal toward monetary easing in advance, and the commitment effect to alter market expectations had largely been realized when the quantitative monetary easing started.

The second bottom panel displays *SL* or $\arctan(r'(2*\tau_2))$ that indicates the flatness of the instantaneous curve in the mid- to long-term. *SL* declined significantly three times, which corresponds to the three rising phases of *PD*. However, it should be noted that there is a major difference between the first phase and the second and third phases. The first decline, after the launch of the zero interest rate policy, rebounded later, as business conditions recovered, especially after spring of 2000. In contrast, the second decline did not seem to accompany a significant rebound, and the third decline still continues as of February 2003, which is the end of the sample period for our estimations.

The bottom panel shows *LFR* or β_0 that is a proxy for the summation of expected inflation and expected economic growth, or expected nominal economic growth. *LFR* showed a general downward trend since 2000, with some cyclical ups and downs around this downward trend. It should be stressed that declines become larger as time passes, while rebounds become weaker. Moreover, major decline occurred after the turn of the year 2003, reflecting prolonged deflationary expectations in the financial markets.

To sum up, we see from the figure that *PD* generally increases over time, while the other three indicators *R*(*PD*), *SL* and *LFR* decrease. Increased *PD* and decreased *R*(*PD*) indicate that the IFR curve in the short end becomes more flattened, and lowered *SL* and *LFR* imply that the IFR curve in the longer end also becomes flattened. This implies that while the quantitative monetary easing has strengthened the policy duration effect, and, at the same time, the market expectations that deflation and low economic growth will last for a considerable period of time in the future are hardly reversed.

B. Short-term Changes in Indicators for the Policy Duration Effect

Next, we employ case study analyses to detect the impacts of changes in monetary policy in the short run. To this end, we focus on the short-term effects of seven major policy changes as well as two Japanese Government actions and a large external shock since 1999 (policy changes A-G and other events R1-3 in Table 1).

Figure 7 plots four indicators, *PD*, *R*(*PD*), *SL* and *LFR*, for the period 20 days prior as well as 40 days past each policy event. In each panel, a solid line shows the estimated parameters, and shaded lines show the upper and lower bounds of their confidence intervals, created by adding and subtracting two times the standard errors of the estimated coefficients. The solid horizontal line indicates the estimates of each indicator at the event date.

1. Period of the zero interest rate policy

Let us first look at Panels A-C, which cover the period of the zero interest rate policy. In Panel A for the launch of the zero interest rate policy on February 12, 1999, the most striking impact was observed in the sharp decline in *R*(*PD*). In addition, *PD* increased steadily, while *SL* and *LFR* fluctuated but did not initially show a clear shift up or down. At this time, although the impact of the policy change appeared immediately in the shape of the IFR curve in the short end, it did not result in altering the market expectations, witnessed in the shape of the curve in the long end.

In Panel B for Governor Hayami's announcement on April 13, *R*(*PD*) showed a significant decline after 15 days. This seems to suggest that time was needed to digest the policy announcement that the BOJ would commit to a zero interest rate "until deflationary concerns are dispelled." In the mean time *PD* remained almost unchanged, and *SL* and *LFR* showed some declines, but rebounded shortly.

In Panel C for the termination of the zero interest rate policy, *R*(*PD*) soared just before the termination, and *LFR* also shifted upward subsequently. Thus, the termination seemed to produce a positive impact on the market expectations regarding the future course of the economy.

2. Period of the quantitative monetary easing

We now turn to Panels D-G for the period of the quantitative monetary easing. In Panel D for the launch of the quantitative monetary easing, the increase in *PD* was barely significant, while the decline in *R*(*PD*) was insignificant. This was due to the fact that the yield curve started flattening prior to the launch of the quantitative monetary easing, possibly reflecting growing market expectations for monetary easing. In response, *LFR* increased slightly, thus indicating that stimulative impact was limited from an early stage.

In Panels E and F for the raising of the target of the current account balance in August and December of 2001 respectively, the impacts on the IFR curve in the short end as well as longer end are insignificant, except for *PD* and *SL* in Panel F. In Panel F, declined *PD* and increased *SL* suggest some positive impacts appeared in the short term.

In Panel G for the further increase in the target of the current account balance in October 2002, the most striking changes appeared in the shape of the IFR curve in the longer end. That is, in contrast to the previous panels, both *SL* and *LFR* declined after the policy changes. In addition, *R*(*PD*) increased statistically significantly but only slightly in magnitude, say some basis points, while *PD* remained almost unchanged. This implies that expansion of the quantitative monetary easing at that time was hardly perceived as effective enough to cancel out the worsening of economic conditions and, thus, failed to reverse deflation expectations in the financial markets.

3. Response to the Japanese Government's action and an external shock

Let us examine next for a moment the response of the IFR curve to the Japanese Government's action as well as a significant external shock. We take up three events, shown in panels R1-3 in Figure 7, as follows: (i) the publication of the "Outline of Basic Policies for Macroeconomic Management and Structural Reform of the Japanese Economy" on June 26, 2001; (ii) September 11 shock of the terror attack in the U.S.; and (iii) the publication of the "Program for Financial Revival" on October 30, 2002.

Among the two actions, only the first one, publication on the Outline, is deemed to produce a positive impact on the market expectation regarding the future course of the economy. In the Panel R1, *LFR* significantly increased, while it marginally declined in Panel R2 and R3. Also *R*(*PD*) in Panel R2 remained almost unchanged, suggesting that to some extent stability was maintained in spite of terror attack shocks on September 11.

V. Concluding Remarks

In this paper, we have examined the policy commitment effect, or policy duration effect of recent monetary policy in Japan, which is characterized by the unusual environment of zero nominal short-term interest rates.

The policy duration effect was highly effective in stabilizing market expectations regarding the future path of short-term interest rates, thereby bringing longer-term interest rates down to flatten the yield curve. In fact, this policy has played a certain role in bolstering Japan's economy, such as stabilizing the financial system.

However, such easing effects failed to be transmitted outside the financial system in Japan, since the transmission channel linking the financial and non-financial sectors remained blocked. As a result, monetary policy alone could not resolve deflation, coupled with low economic growth, and failed to reverse deflationary expectations in the financial markets. As we have shown, the expectation of prolonged deflation is observed most typically in lowered long-term interest rates, indicating financial market expectations that deflation will continue for years, rather than be quickly reversed.

Furthermore, the quantitative monetary easing resulted in reducing the incentive for financial institutions to assume interest rate risks. As market expectations of prolonged zero interest rates are intensified, financial institutions are inclined to purchase JGBs with less concern about their interest rate risks and potential capital losses. In fact, they are less likely to hedge their interest rate risks from a massive purchase of JGBs by swapping fixed rates in exchange for floating rates. As a result, the yen swap rate declined substantially from mid-1999, and the yen swap spread, defined as the difference between the yen swap rate and the JGB rate at the same maturity, has been reduced below zero since the end of 2001, as shown in Figure 8. This observation implies that interbank markets not only for short-term contracts but also longer-term contracts have almost stopped functioning as a risk-sharing device among financial institutions and are insensitive to interest risks.

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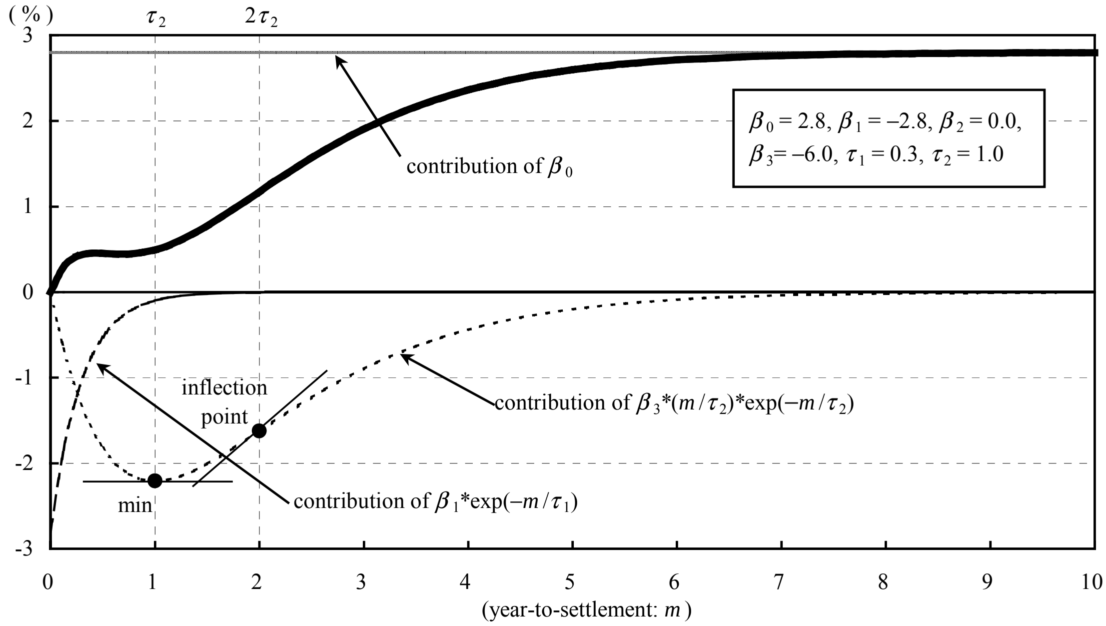
Table 1. Policy Events

ID	Date	Changes in Policy Guidelines
	September 9, 1998	Reduction of targeted O/N rate (0.5 → 0.25 %)
	November 13, 1998	Introduction of new money market operations
A	February 12, 1999	Introduction of zero interest rate policy
B	April 13, 1999	Governor’s announcement of the commitment to zero interest rate until deflationary concerns are dispelled
	October 13, 1999	Expansion of the range of money market operations
C	August 11, 2000	Termination of zero interest rate policy
	February 9, 2001	Reduction of ODR (0.5→0.375%), introduction of new way of liquidity provision
	February 28, 2001	Reduction of targeted O/N rate (0.25→0.125%) and ODR (0.375→0.25%)
D	March 19, 2001	Decision to introduce quantitative monetary easing policy
R1	(June 26, 2001)	(Publication of the “Outline of Basic Policies for Macroeconomic Management and Structural Reform of the Japanese Economy”)
E	August 14, 2001	Raise of the target CAB (5→6 trill. yen)
R2	(September 11, 2001)	Terror Attacks in US on September 11
	September 18, 2001	Raise of the target CAB (6→above 6 trill. Yen)
F	December 19, 2001	Raise of the target CAB (above 6→10-15 trill. yen)
	September 18, 2002	Introduction of stock purchasing plan
R3	(October 30, 2002)	(Publication of the “Program for Financial Revival”)
G	October 30, 2002	Raise of the target CAB (10-15→15-20 trill. yen)

Figure 1. Illustrated IFR Curve

[A] A typical shape under the zero interest rate policy and the quantitative monetary easing



[B] A complex shape in the case of liquidity events

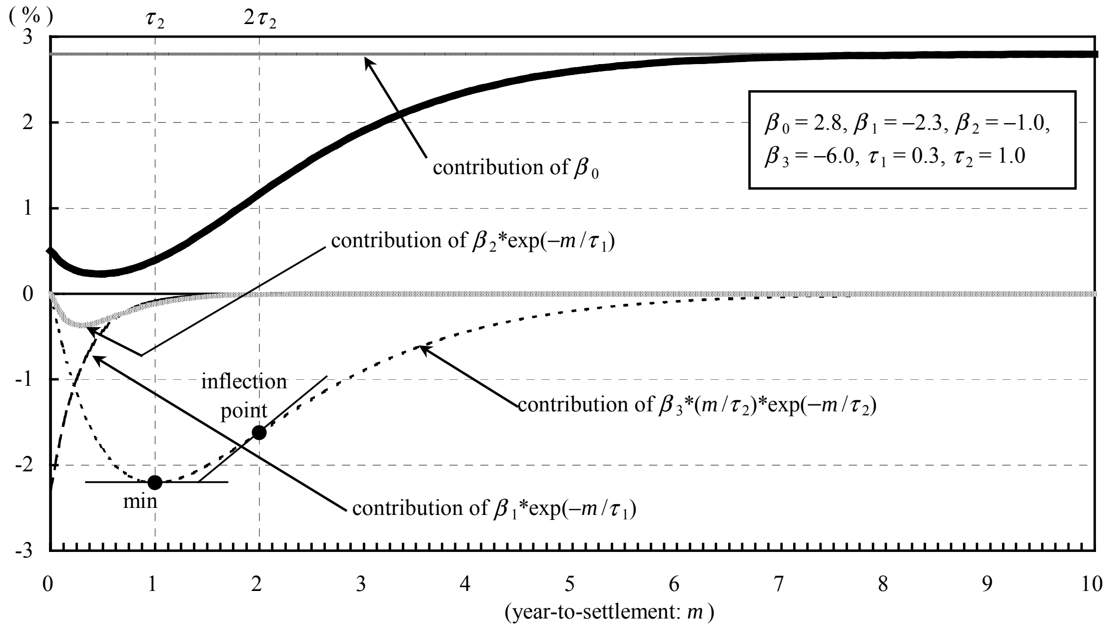


Figure 2. Indicator for the Policy Duration Effect (Illustration)

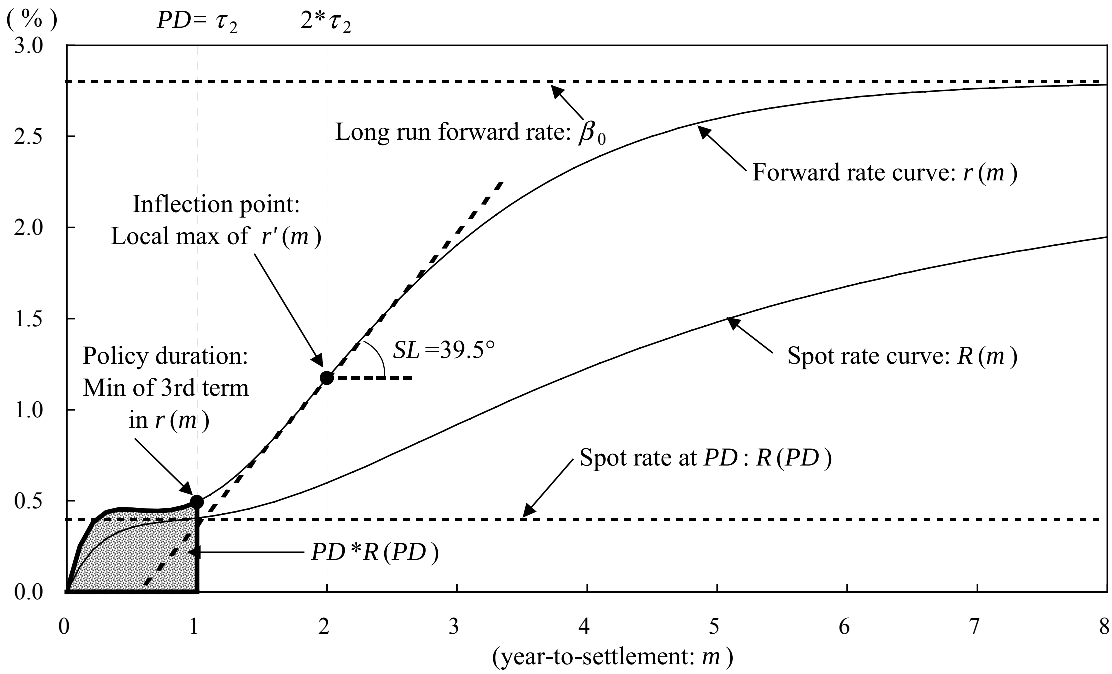
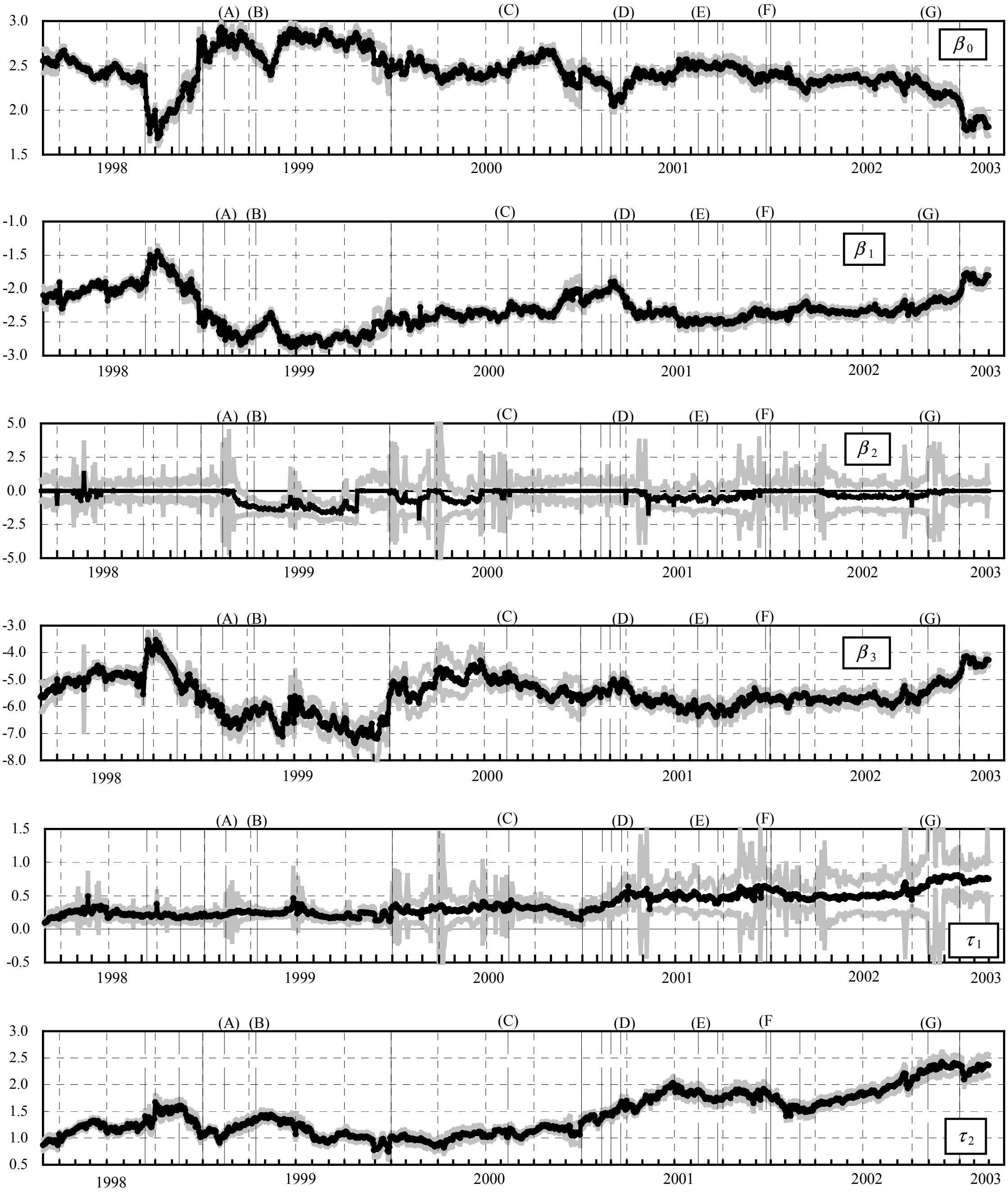


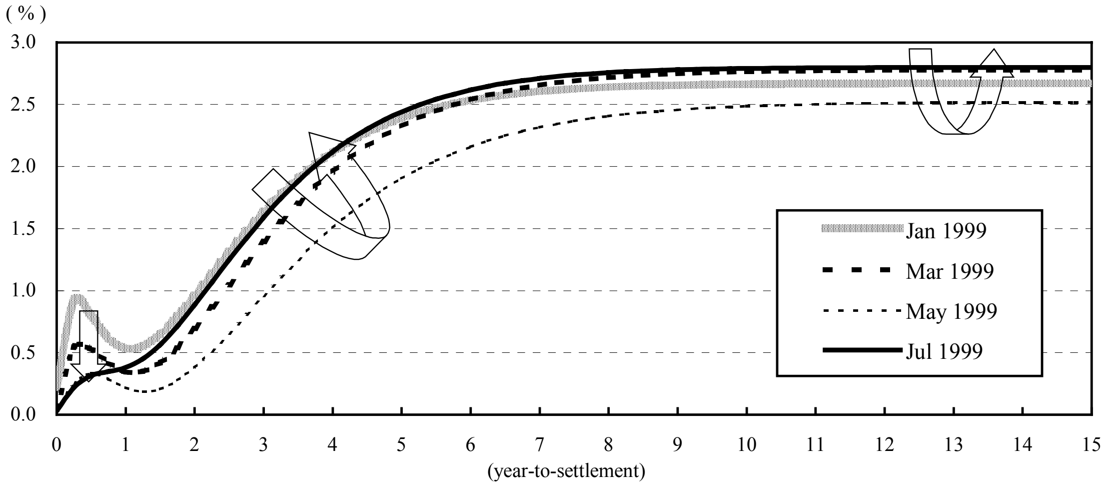
Figure 3. Estimated Coefficients for NS Model



Note: 1. Bold lines are estimated coefficients, and shaded lines indicate their upper and lower bounds respectively of the confidence interval (estimated coefficients ± 2*standard errors).
2. The solid and dotted vertical lines respectively indicate the end of year and that of quarter.
3. The dashed vertical lines indicate the date of the policy changes, summarized in Table 1. The labeled dashed vertical lines from (A) to (G) correspond to the major policy changes in the same table.

Figure 4. Simulated IFR Curve (1):
Period of the Zero Interest Rate Policy from February 1999 to August 2000

[A] Introduction of the zero interest rate policy



[B] Termination of the zero interest rate policy

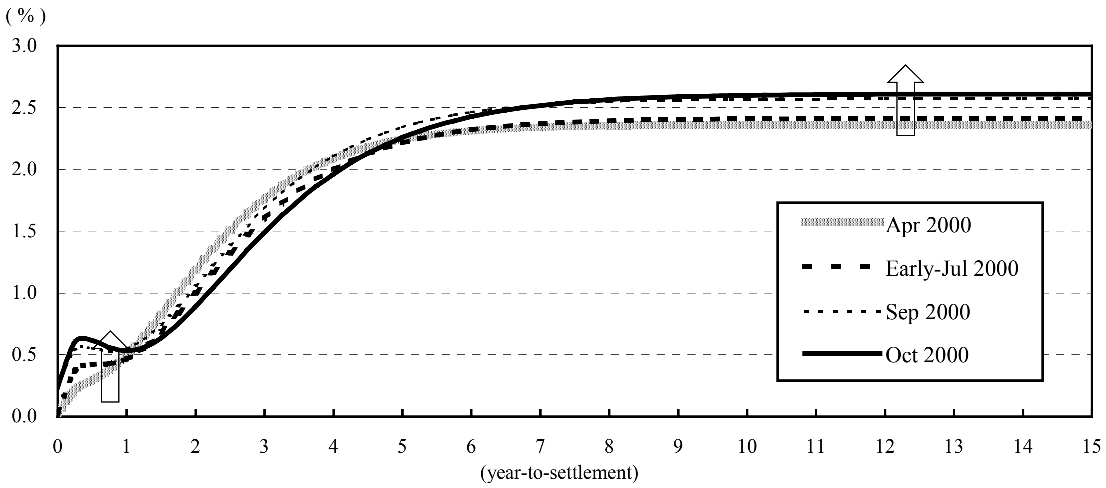
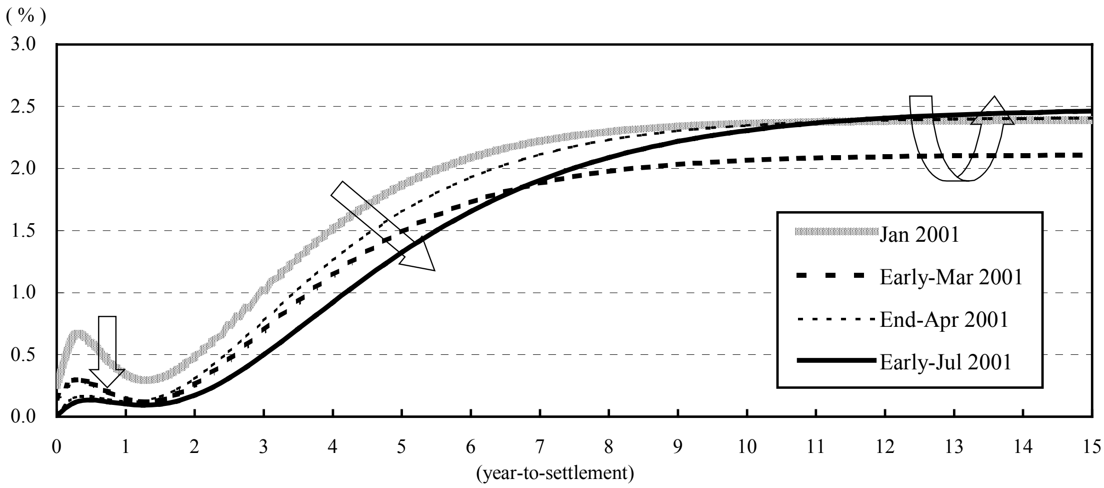
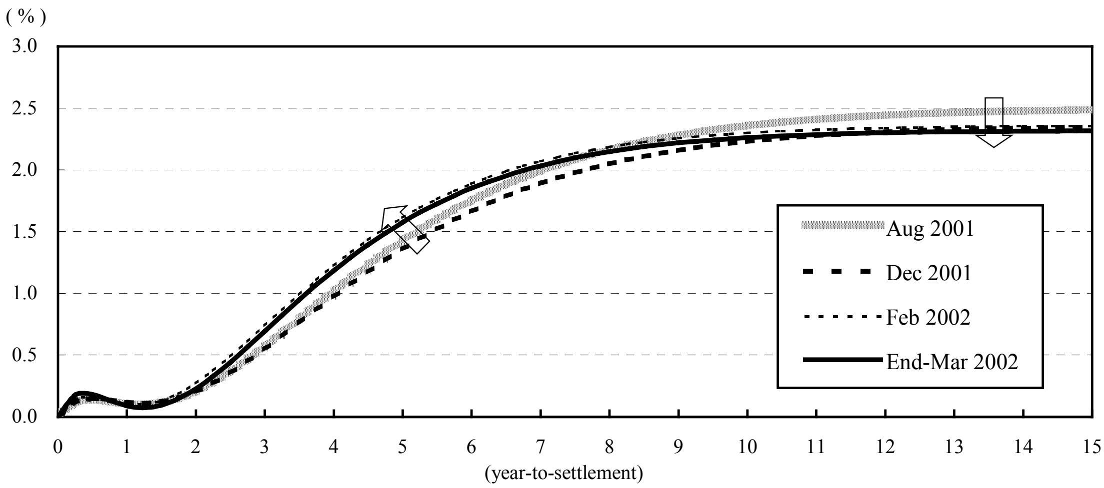


Figure 5. Simulated IFR Curve (2):
Period of the Quantitative Monetary Easing since March 2001

[A] Introduction of the quantitative monetary easing



[B] Initial stage of aggressive expansion of monetary base



[C] Recent phase

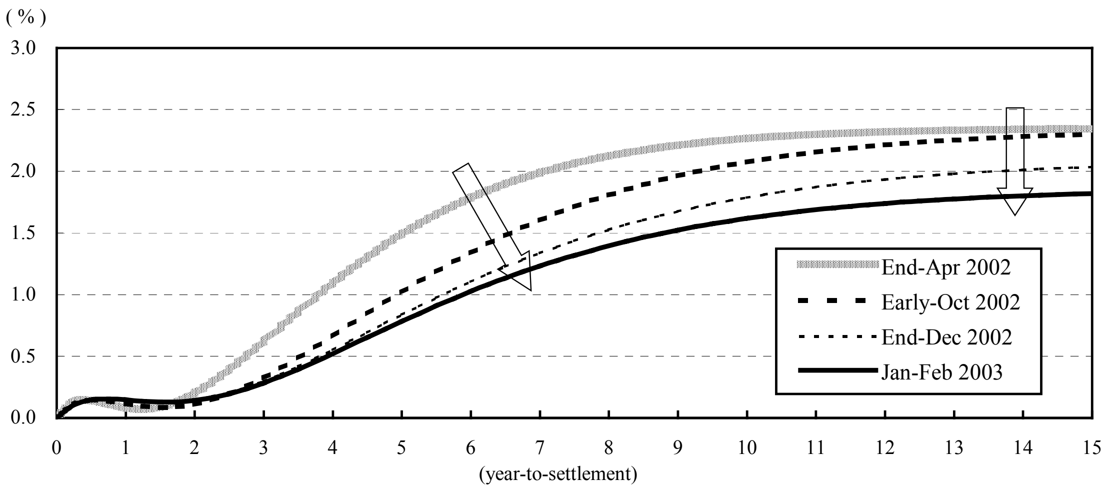
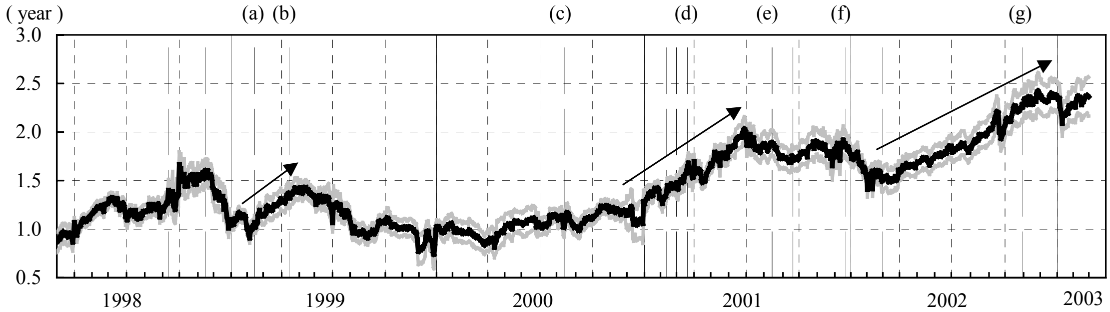
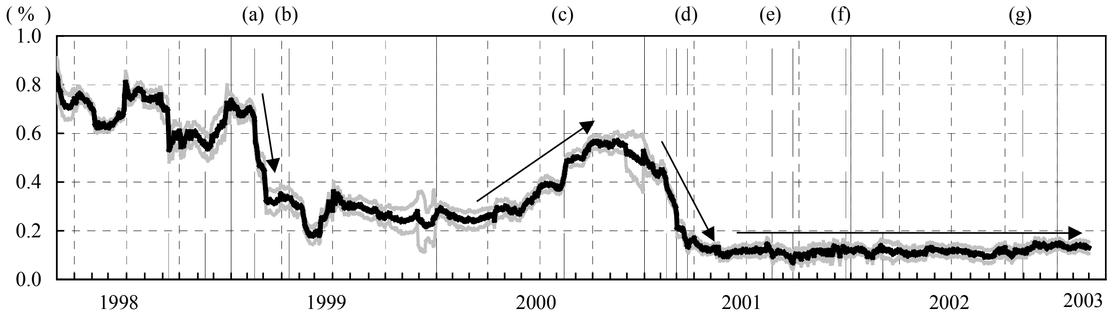


Figure 6. The Policy Duration Effect

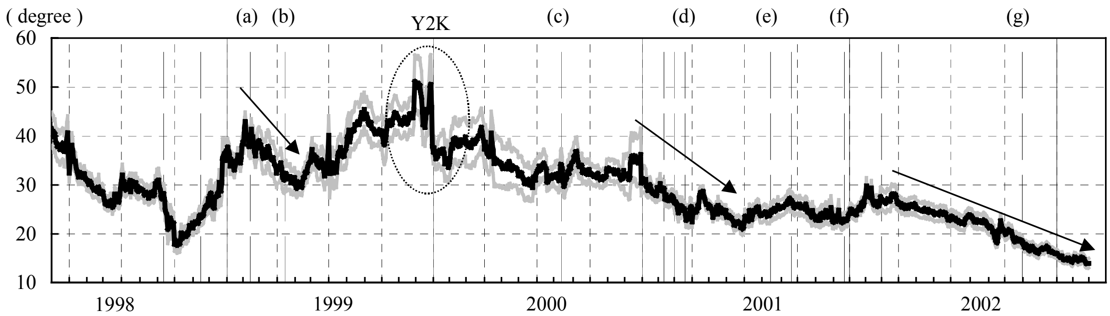
[1] Policy duration: *PD*



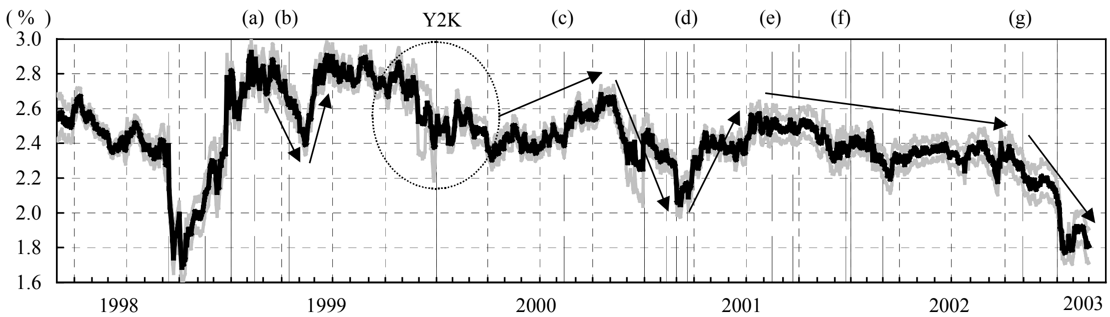
[2] Estimated spot rate at policy duration: *R*(*PD*)



[3] Slope of forward rate curve at inflection point: *SL*



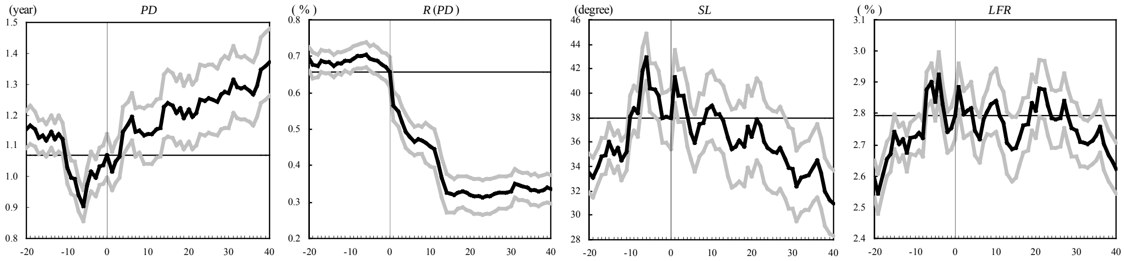
[4] Estimated long-term forward rate: *LFR*



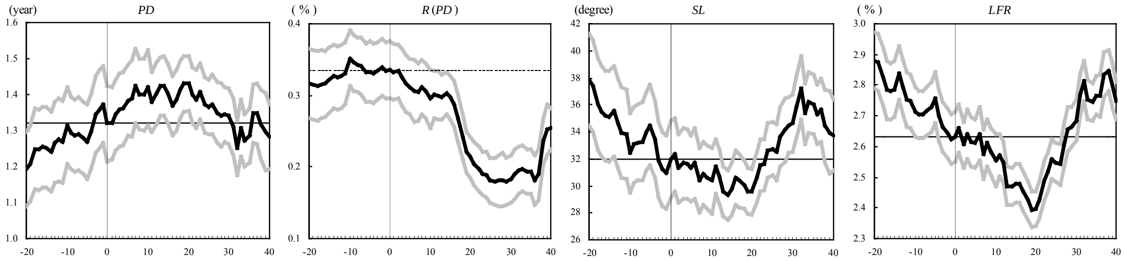
Note: 1. The solid and dotted vertical lines respectively indicate the end of year and that of quarter.
2. The dashed vertical lines indicate the date of the policy changes, summarized in Table 1. The labeled dashed vertical lines from (a) to (g) correspond to the major policy changes in the same table.

Figure 7. Response of the Yield Curve to Policy Changes

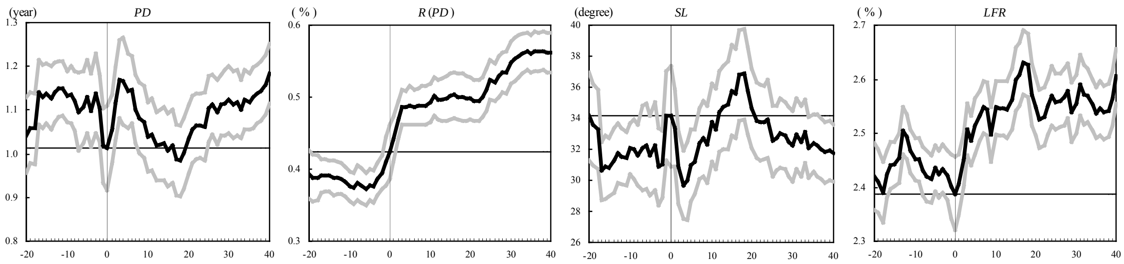
[A] Policy event A: February 12, 1999



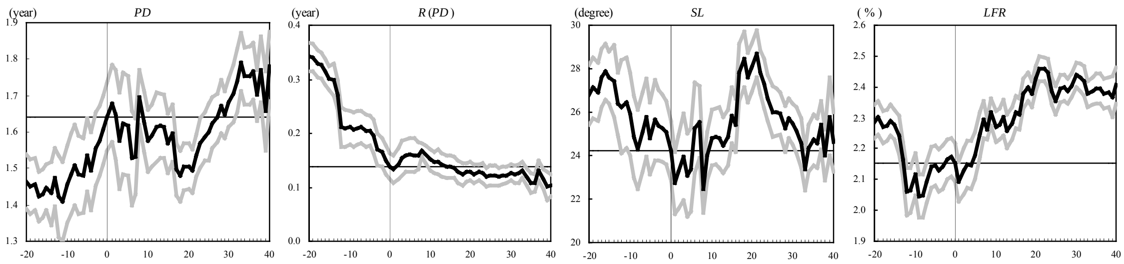
[B] Policy event B: April 13, 1999



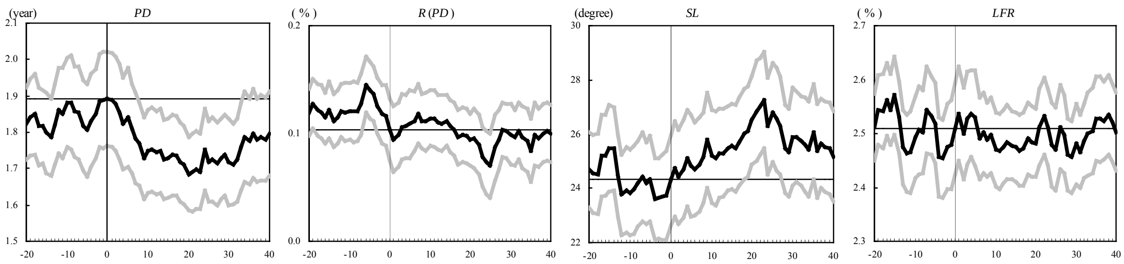
[C] Policy event C: August 11, 2000



[D] Policy event D: March 19, 2001



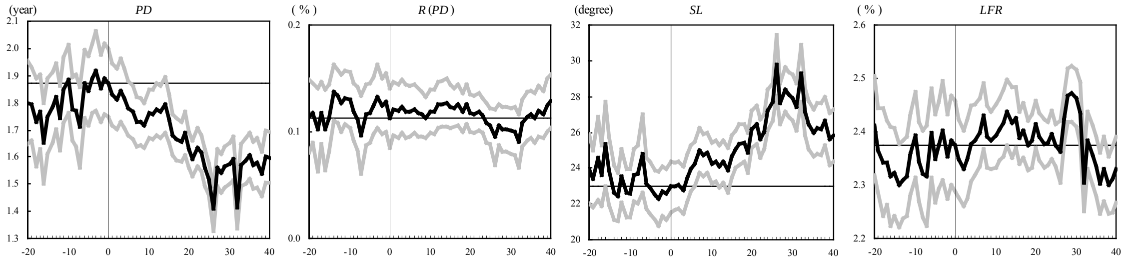
[E] Policy event E: August 14, 2001



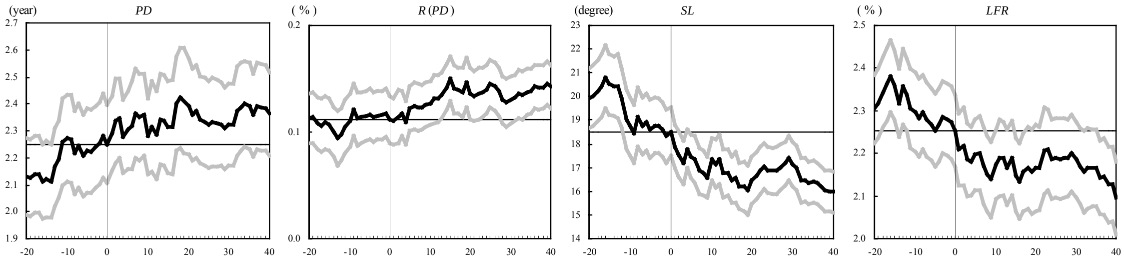
Note: The vertical line indicates the policy event that corresponds to zero in the horizontal axis. The solid line corresponds to mean of the plotted values for 20- to 1-day prior to the policy event. The dashed lines respectively indicate the upper and lower bounds of 95-percent confidence interval for the mean.

Figure 7 (continued)

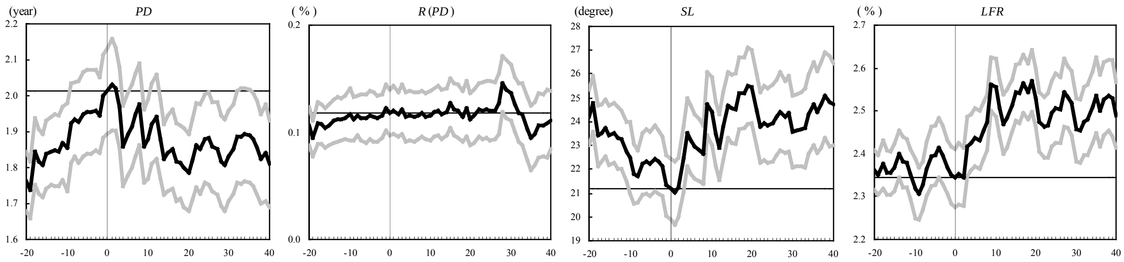
[F] Policy event F: December 19, 2001



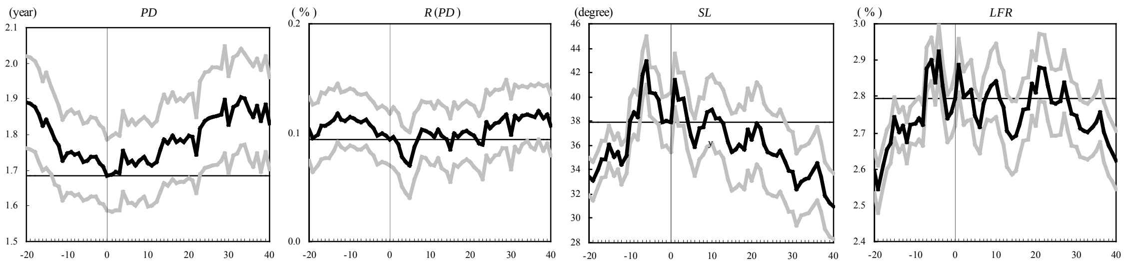
[G] Policy event G: October 30, 2002



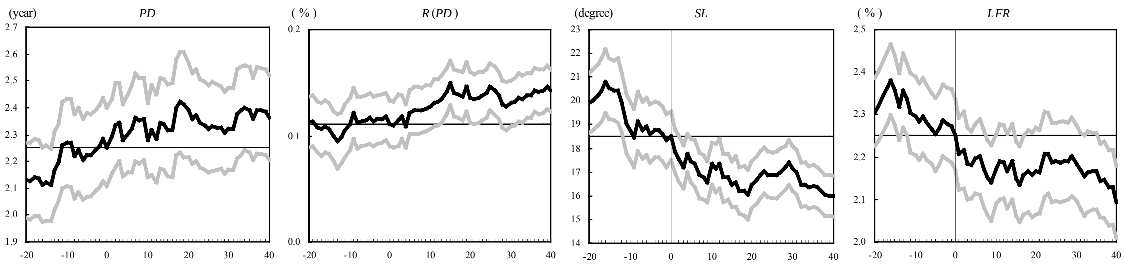
[R1] Publication of Outline of Basic Policies: June 26, 2001



[R2] September 11: September 11, 2001

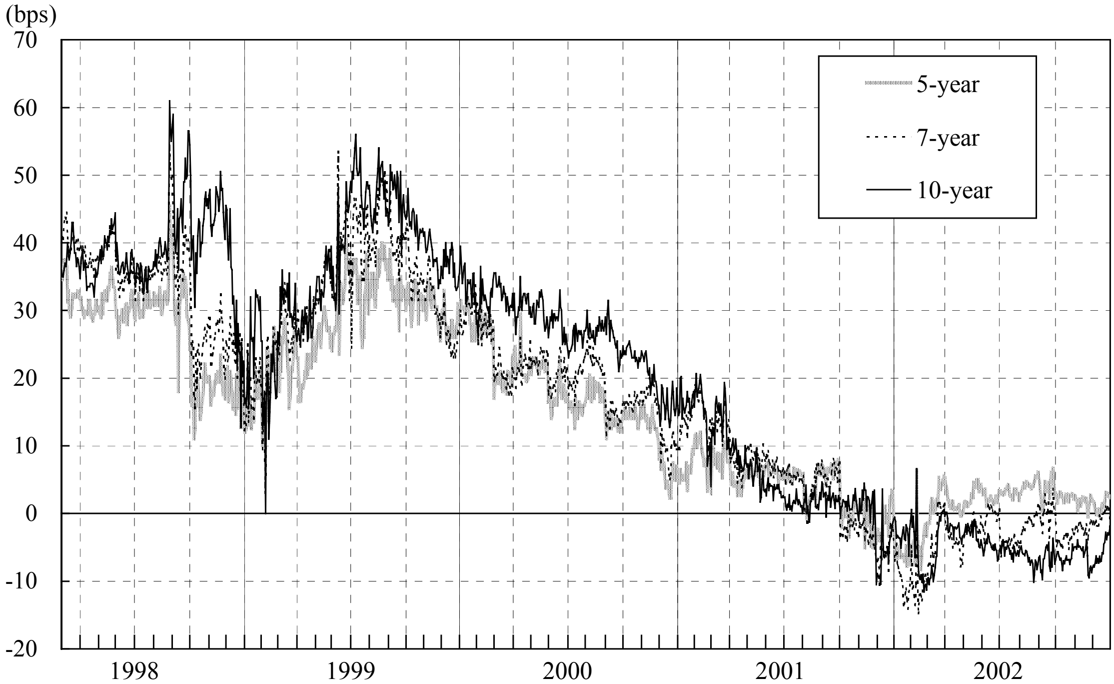


[R3] Publication of Program for Financial Revival: October 30, 2002



Note: The vertical line indicates the policy event that corresponds to zero in the horizontal axis. The solid line corresponds to mean of the plotted values for 20- to 1-day prior to the policy event. The dashed lines respectively indicate the upper and lower bounds of 95-percent confidence interval for the mean.

Figure 8.   Yen Swap Spreads



Source: Bloomberg.