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The Effects of the Bank of Japan's Zero Interest Rate Commitment and Quantitative Monetary Easing on the Yield Curve: A Macro-Finance Approach

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Abstract

This paper provides an empirical investigation of monetary policy in Japan in the zero interest rate environment that has held sway since 1999. In particular, we focus on the effects of the zero interest rate commitment and of quantitative monetary easing on medium- to long-term interest rates in Japan. In the study we apply a version of the macro-finance approach, involving a combination of estimation of a structural macro-model and calibration of time-variant parameters to the yield curve observed in the market. This enables us to decompose interest rates into expectations and risk premium components and simultaneously to extract the market's perception of the Bank of Japan's (BOJ's) willingness to carry on its zero interest rate policy. In the analysis we make clear the counterfactual policy that would have been practiced in the absence of the actual policies followed by the BOJ since 1999. From this analysis, we tentatively conclude that the BOJ's monetary policy since 1999 has functioned mainly through the zero interest rate commitment, which has led to declines in medium- to long-term interest rates. We also find some evidence that, up until the end of 2003, raising the reserve target may have been perceived as a signal indicating the BOJ's accommodative policy stance although the size of the effect is not large. The portfolio rebalancing effect -- either by the BOJ's supplying ample liquidity or by its purchases of long-term government bonds -- has not been found to be significant.

Keywords: Zero interest rate policy (ZIRP); Quantitative monetary easing policy (QMEP); Zero interest rate commitment; Policy duration effect; Macro-finance model; Expectations theory; Monetary policy rule

JEL Classification: E43, E52, E58, G12

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1. Introduction

This paper provides an empirical investigation of the effects on interest rates of the Bank of Japan (BOJ)'s monetary policy adopted since it lowered the short-term policy rate to nearly zero in 1999. The BOJ has carried out essentially two types of policy during the period. First, it has made the so-called zero rate commitment, with the exception of August 2000-March 2001, roughly defined as the BOJ's promise to keep its policy rate at zero as long as the economy experiences deflation. Second, the BOJ has supplied more bank reserves (or more strictly, the current account balances at the BOJ) than necessary to maintain the short-term interest rate at zero since March 2001. While these policies are considered to have influenced a variety of macroeconomic variables, this paper focuses on their effects on medium- to long-term interest rates on government bonds. This is because these rates are likely to reflect most vividly the market's perception of current and future monetary policy stance, thus enabling convenient empirical examination of this perception with a relatively small data set. Needless to say, these interest rates are at the core of the transmission process of monetary policy on the economy.

A number of authors recently studied the topic of monetary policy under the zero lower bound of nominal interest rates. For example, Eggertsson and Woodford (2003) and Jung, Teranishi, and Watanabe (forthcoming) pointed out the importance and effectiveness of expectations management in terms of the conduct of monetary policy from a theoretical perspective. Bernanke and Reinhart (2004), Clouse *et al*. (2003), Shirakawa (2002), Meltzer (2001), Oda and Okina (2001), and Svensson (2001) presented mainly theoretical or conceptual analyses of alternative strategies for further monetary easing under the zero interest rate environment. The empirical examination of the effectiveness of the zero rate commitment or of the QMEP, however, is relatively limited, reflecting the unprecedented nature of the recent Japanese situation and thus the limited availability of data. Even with this constraint, Fujiki and Shiratsuka (2002) and Okina and Shiratsuka (2004) argued that the zero rate commitment in Japan flattened the yield curve. Kimura *et al*. (2002) examined whether, apart from the conventional interest rate channel, increases in the monetary base had any expansionary effect on aggregate demand and concluded that such effect, if any, in Japan was extremely small and uncertain. More recently, Bernanke, Reinhart, and Sack (2004) conducted an empirical assessment of these effects for both the United States and Japan with an "event study" approach and a "macro-finance," no-arbitrage model of the term structure, and found some evidence that central bank communications could help to shape public expectations of future policy actions. The authors also concluded that asset purchases in large volume by a central bank would have been able to affect the price or yield of the target asset, especially in the case of the United States, while the evidence on the effectiveness of these policies was more mixed for Japan.

Our paper also uses a version of the macro-finance, no-arbitrage model of the term structure to assess the effectiveness of the BOJ's policies so far adopted[1]. The major contribution of this paper is the explicit modeling of the counterfactual, i.e., the monetary policy rule that would have been adopted in the absence of the kind of commitment the BOJ has made. By doing so, we are able to estimate more precisely than other authors the effect of the commitment on interest rates. In our formulation of the policy that the BOJ has adopted and the counterfactual, we take into account explicitly the non-linearity of the rules arising from the zero lower bound on nominal interest rates. In contrast, Bernanke, Reinhart, and Sack (2004) formulated a monetary policy rule, in the framework of a vector autoregression, that takes account of a zero lower bound but does not explicitly involve the zero rate commitment. We consider our formulation to be effective in distinguishing the effects of the zero rate commitment from other factors, and thus more effective in assessing the independent effects of QMEP as well.

To preview the conclusion of this paper briefly, the BOJ's monetary policy under the zero interest rate environment since 1999 has functioned mainly through the zero rate commitment, which has reduced medium- to long-term interest rates. The portfolio rebalancing effect -- either by the BOJ's ample supply of liquidity or by its purchases of long-term government bonds (JGBs [Japanese government bonds]) -- on the risk premium component of interest rates has not been found to be significant. There is some evidence that raising the reserve target has been perceived by the market as a signal indicating the BOJ's greater willingness to carry on QMEP and thus enhanced the effects of the zero rate commitment, although this interpretation is subject to further examination.

The remainder of this paper is organized as follows. In section 2, we discuss the recent development of Japan's economy and monetary policy as a background for analysis. Section 3 presents our methodology of analysis, including model estimation and simulation procedures. In section 4, we present the results of decomposition of the

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[1] The macro-finance approach, which was recently broadened by the important work of Ang and Piazzesi (2003) and Piazzesi (2005), has the advantage of using market data in combination with macroeconomic data, and is thus effective in analyzing the effects of the economic structure and monetary policy on long-term interest rates.

medium- to long-term interest rates in Japan into expectations and risk premium components, and assess the effect of the zero interest rate commitment. In section 5, we conduct a regression analysis of the effects of QMEP, focusing on the expansion of reserves at the BOJ and the increase in its purchase of JGBs. Finally, in section 6, we summarize our analyses and consider issues for future study.

2. Background: The Japanese Economy and Monetary Policy in the Recent Era

2. 1 Recent Development of the Economy and Monetary Policy in Japan

Here we will provide an overview of the recent development of the economy and of monetary policy in Japan. Since the burst of the asset price bubble in the early 1990s, Japan has been experiencing a long economic slump. The slump is characterized by several deep cyclical downturns that were followed by modest short-lived economic recoveries. Real GDP grew at an anemic 1% on average for 1991-2002 Movements of the rate of change of GDP and CPI in this period are shown in **Figure 1** (i). There is a consensus among economists that one of the basic structural problems in Japan has been the non-performing loans in the banking sector which reflected excessive debts in the corporate sector.[2] The impaired balance sheets of the sectors have prevented the transmission mechanism of monetary easing from working smoothly. In addition, the BOJ has faced the zero lower bound constraint on nominal interest rates since 1999. Thus, as **Figure 1** (ii) presents, the ratio of the monetary base to nominal GDP has moved sharply upward since the mid 1990s, and the rate of growth of bank loans has been either near zero or negative since 1994. The money supply (M2+CD) has grown at much lower rates than the monetary base, as shown in **Figure 1** (iii), that is, the money multiplier has declined sharply.

In terms of monetary policy, as **Figure 1** (ii) shows, the BOJ had little room for further reductions in interest rates as early as 1995. The BOJ maintained the uncollateralized overnight call rate as low as approximately 0.5 percent from September 1995 to September 1998 to stimulate the economy and to contain the strains in the financial system generated by failures of large financial institutions during this period. The BOJ then successively lowered the overnight call rate to virtually zero percent in February 1999. The so-called zero interest rate policy (ZIRP) had been implemented

[2] Details on the banking problems in Japan in the 1990s are explained by Ueda (2000).

in the period between April 1999 and August 2000.[3] The ZIRP was not just a zero short-term interest rate, but a commitment to maintain it until a pre-announced condition was fulfilled. Specifically, the BOJ Governor announced in April 1999 that the Bank would continue the zero rate until deflationary concerns were dispelled. This can be interpreted as an example of the zero rate commitment to be more formally analyzed later in this paper. In August 2000, the BOJ lifted the ZIRP and raised the overnight call rate to 0.25 percent, since the economy was recovering and showing some signs of overcoming deflation. In late 2000, however, the economy began to deteriorate again, reflecting a global decline in the demand for IT goods, raising deflationary concerns again. The BOJ lowered the policy interest rate to 0.15 percent, and then adopted the QMEP in March 2001. The QMEP is still in effect as of the writing of this article (April 2005).

The QMEP has consisted of three pillars. First, the BOJ has maintained an ample liquidity supply by using the current account balances (CABs) at the BOJ as the main operating policy target. Second, the BOJ has commited itself to maintaining the provision of ample liquidity until the rate of change of the core CPI (nationwide, excluding perishables) becomes zero percent or higher on a sustained basis. Third, the BOJ has increased the amount of purchases of JGBs from time to time as a tool for liquidity injection. It was projected that increasing the CAB targets beyond the level of the required reserves would normally keep the call rate near zero percent.[4] Thus, if one focuses on the policy interest rate, the QMEP can be interpreted as a revised version of the ZIRP (RZIRP), which also contains the provision of a zero rate commitment.[5] The details of this commitment were further clarified in October 2003, with the BOJ stating its intention to continue providing ample liquidity until both actual and expected inflation become zero percent or higher.[6]

Figure 2 shows the evolution of the target and actual CABs under the QMEP in Japan.[7] The target CABs increased from approximately 5 trillion yen at the

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[3] See, for example, Ueda (2002) regarding monetary policy in Japan in this period.

[4] In fact, the uncollateralized overnight call rate declined to 0.001 or 0.002 percent, almost literally to zero percent, during the QMEP period, while it declined to at most 0.01 percent during the ZIRP period.

[5] The effect of the zero rate commitment on the private sector's expectations of future policy rate is often called "Jikan-jiku Koka" ("policy duration effect") in Japan.

[6] For further details on the QMEP, see the BOJ's website (http://www.boj.or.jp).

[7] The actual CABs at the BOJ on a quarterly average basis, adjusted to exclude the effects of Y2K and semiannual book closings, are shown in **Figure 10**.

introduction of the QMEP in March 2001, an amount roughly 1 trillion yen greater than the then-required CABs, to a range of approximately 30-35 trillion yen in January 2004.[8] The increases in CABs have been provided mainly by market operations, including the BOJ's purchases of JGBs. The amount of monthly purchases of JGBs has been set and pre-announced by the BOJ. This amount was equivalent to 0.4 trillion yen per month in March 2001 and was gradually increased to 1.2 trillion yen by May 2004.[9]

2. 2 Possible Transmission Channels of Monetary Policy under the Zero Interest Rate Environment in Terms of Effects on Long-Term Interest Rates

We will now provide an overview of the possible transmission channels of the ZIRP and QMEP in Japan with reference to Bernanke and Reinhart's (2004) discussion. While each channel would have its own benefits and costs, this paper focuses on the investigation of the degree of benefit, that is, the effect of lowering long-term rates.

Bernanke and Reinhart (2004) presented three alternative monetary strategies for stimulating the economy without lowering the current policy rate. They were: (i) shaping interest-rate expectations -- that is, providing assurance to the private sector that policy rates will be lower in the future than currently expected; (ii) altering the composition of the central bank's balance sheet to change the relative supplies of securities in the market; and (iii) expanding the size of the central bank's balance sheet beyond the level required to set the short-term policy rate at zero. The ZIRP and the RZIRP component of QMEP are examples of strategy (i). While it seems that the theoretical foundation has been established for the effectiveness of strategy (i) in general, the effectiveness of its specific application in Japan will be assessed in section 4 of this paper.[10] As a possible case of adoption of strategy (ii), we can consider the increase in the BOJ's purchases of JGBs in the QMEP period. Such an increase may generate portfolio rebalancing effects, although none of the BOJ's statements have mentioned any intent to produce this sort of effect. We will assess the significance of

[8] Regarding the demand and supply of central bank reserves near zero interest rates, Oda (2002) provides a theoretical perspective based on Japan's experience. As for the technical aspects of open market operations under the QMEP, Maeda *et al*. (2005) provide explanations based on their experience at the BOJ's Operations Desk.

[9] Actual purchases on a quarterly basis are presented in **Figure 12** (i).

[10] While section 4 of this paper assesses the effect of the zero rate commitment in terms of its influence on long-term interest rates, Oda and Nagahata (2005) investigate the effect of the commitment on macroeconomic variables from a perspective of social welfare.

this possibility in subsection 5.2. Regarding strategy (iii), an example of which is the expansion of the CABs at the BOJ in the QMEP period, Bernanke and Reinhart (2004) further discussed three possible channels: (a) the portfolio rebalancing effect, whereby the increases in the monetary base would lead the private sector to rebalance its portfolios, lowering yields on alternative, non-monetary assets; (b) altering expectations of the future path of policy rates by a visible act of setting and meeting a high reserve target; and (c) the expansionary fiscal effect, whereby the central bank replaces public holdings of interest-bearing government debt with non-interest-bearing currency or reserves, thus replacing the expected future tax liability for the public with an inflation tax. In this paper, the effectiveness of channel (a) in the case of Japan's QMEP will be assessed in subsection 5.2. The effectiveness of channel (b), which we call the signaling effect, will be investigated for the case of Japan in subsection 5.1. In addition, we also consider whether or not a similar signaling effect can be found with respect to the increase in the BOJ's purchase of JGBs, instead of in the expansion of its overall balance sheet, in this subsection. We will not examine the effectiveness of channel (c) in this paper.

3. Methodology

This section presents the methodology used to decompose long-term interest rates into expectations and risk premium components. Here we will use a macro-finance model[11], building on Oda and Kobayashi (2003), that combines a small macroeconomic model with a finance theory approach.

3. 1 Model of the Economy

We assume a small backward-looking model, shown by equations (1)-(7) below, consisting of aggregate demand and supply equations (IS/AS) and a monetary policy rule (MP). The IS and AS equations are both of simple backward-looking types, whereby the present GDP gap is determined by past GDP gaps and real interest rates and the present inflation rate is determined by past inflation rates and GDP gap.

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[11] Examples of the application of the macro-finance approach to studies of the effects of monetary policy include Rudebusch and Wu (2003) and Hördahl, Tristani, and Vestin (2004). The analysis in this paper is different from these earlier reports in its explicit recognition of the nonlinearity of the monetary policy rule, i.e., the zero lower bound on nominal interest rates and the zero rate commitment by the BOJ.

Demand and supply shocks are assumed to be AR(1) processes. In terms of monetary policy, the default policy rule (a "type 1 rule") is set as a modified Taylor rule, that incorporates slow policy adjustment and recognizes the zero lower bound constraint on nominal interest rates. The BOJ's commitment to maintaining a zero short rate until consumer price inflation becomes positive (the ZIRP/RZIRP) is modeled as the maintenance of a zero rate until inflation exceeds the threshold rate (x) under the "type 2 rule,"[12] which is applied for the relevant periods: 1999/Q2-2000/Q2 and 2001/Q2-the latest quarter (2003/Q4). In other words, the type 1 rule is assumed to be the rule that was in place when the BOJ was not using the type 2 rule. Also, it is used as a counterfactual against which to gauge the effect of the zero rate commitment in the type 2 rule.

The model is estimated by the maximum likelihood method using Japanese data from 1980/Q1 to 1999/Q1. The choice of this estimation period reflects the adoption of the ZIRP in 1999/Q2; thus we simply assume equation (3) below for the estimation of monetary policy, without considering the zero lower bound and the zero rate commitment. In the simulations reported below to analyze the effects of the BOJ's policies after 1999, we do replace the type 1 rule by the type 2 rule, but assume that the parameters of the model remained the same for the period after 1999/Q2. Thus, equation (5) for the type 2 rule is assumed to be the same as the equation (3) for the type 1 rule, for example.

The equations of the estimated model are as follows. Numbers in parentheses are standard errors of each estimate.

(IS)
$$y_t = \underset{(0.102)}{0.735} y_{t-1} + \underset{(0.117)}{0.108} y_{t-2} - \underset{(0.126)}{0.159} \left(\frac{i_{t-1} + i_{t-2}}{2} - \frac{\pi_{t-1} + \pi_{t-2}}{2} - \frac{r^n_{t-1} + r^n_{t-2}}{2} \right) + \varepsilon^d_t , \qquad (1)$$

(AS)
$$\pi_t = \underset{(0.048)}{1.552} \pi_{t-1} - \underset{(0.048)}{0.552} \pi_{t-2} + \underset{(0.042)}{0.008} y_{t-1} + \varepsilon^s_t . \qquad (2)$$

[12] An alternative formulation for the zero rate commitment would be to assume the threshold rate as fixed. This might be more in line with the BOJ's ongoing pronouncements. However, given that the ZIRP was the first such policy implemented, the market's perception of the nature of the framework seems to have evolved over time. Under the RZIRP, the commitment to maintain the QMEP until the CPI "registers stably a zero percent or an increase year on year" on a sustained basis must mean that the threshold rate is positive rather than strictly zero. Moreover, the clarification of the commitment in October 2003 to include a reference to expected inflation may have raised the threshold rate. Thus, it seems plausible to model the threshold rate as time-variant.

(Monetary Policy Rule)

• Type 1: rule without a zero rate commitment (through 1999/Q1 and 2000/Q3-2001/Q1)

$$i_t^* = \underset{(0.079)}{0.723} \cdot i_{t-1}^* + (1 - \underset{(0.079)}{0.723}) \cdot [(r_t^n + \pi_t) + \underset{(0.134)}{0.139}(\pi_t - \pi^*) + \underset{(0.305)}{0.251} y_t], \quad (3)$$

$$i_t = \max[i_t^*, 0]. \quad (4)$$

• Type 2: rule with a zero rate commitment (1999/Q2-2000/Q2 and 2001/Q2-2003/Q4)

$$i_t^* = 0.723 \cdot i_{t-1}^* + (1 - 0.723) \cdot [(r_t^n + \pi_t) + 0.139(\pi_t - \pi^*) + 0.251 y_t], \quad (5)$$

$$\begin{cases} i_t = 0 & \text{if } i_t^* < 0 \text{ or } \overline{\pi}_t < x\% \\ i_t = i_t^* & \text{if } i_t^* \geq 0 \text{ and } \overline{\pi}_t \geq x\% \end{cases} \quad (6)$$

(Disturbances)

Demand shock: $$\varepsilon_{t+1}^d = -\underset{(0.105)}{0.003} \varepsilon_t^d + u_t^d, \quad (7)$$

Supply shock: $$\varepsilon_{t+1}^s = \underset{(0.055)}{0.060} \varepsilon_t^s + u_t^s, \quad (8)$$

where $u_t^d \sim N(0, 0.722)$, $u_t^s \sim N(0, 0.417)$, and $corr(u_t^d, u_t^s) = -0.08$.

<Notation>

y_t: output gap, defined as a percentage deviation from the potential output.

π_t: inflation rate, defined as the year-on-year changes in the CPI (excluding perishables).

r_t^n: natural rate of interest, modeled as $r_t^n = (y_t^* - y_{t-1}^*) + const$.

y_t^*: potential output, defined as a logarithmic value of the HP-filtered real GDP (seasonally adjusted).

i_t: nominal short-term interest rate, defined as the overnight uncollateralized call rate.

i_t^*: nominal short-term interest rate in a case with neither the zero lower bound constraint nor the zero rate commitment.

π_t^*: targeted inflation rate, which is set at 1.81%, the average of the realized rate during the estimation period.

$\overline{\pi}_t$: two-quarter backward moving average of inflation rate.

x: the threshold rate of inflation for exiting the zero rate commitment (also see below).

3. 2 Decomposition of Interest Rates into Expectations and Risk Premium Components by Monte-Carlo Simulation

We combine the macro model, estimated above, with the no-arbitrage asset pricing theory in finance in order to derive a model-based yield curve. We assume that the threshold rate of inflation in the type 2 monetary policy rule, as well as the market prices of risk associated with aggregate demand and supply shocks to the goods market, are time-variant and are estimated simultaneously from the yield curve observed in the market at each point in time.[13] Note that the threshold rate of inflation under the RZIRP can be recognized by market participants to be positive, since the BOJ announced its intention to maintain the RZIRP until the consumer price index (excluding perishables, on a nationwide basis) inflation becomes stably above zero. The perceived threshold rate may change, since the market participants can update their inferences based on developing information regarding the monetary policy stance.

Given the threshold rate and the market prices of risks, the model-based yield curve R_t^T, i.e., the interest rate at t on a bond maturing at T, can be described as follows.

$$\begin{aligned} R_t^T &\equiv -\frac{1}{T-t}\ln P(t,T) \\ &= -\frac{1}{T-t}\ln\, E_t^Q \exp[-\int_t^T \hat{i}_s ds], \end{aligned} \tag{9}$$

where $P(t,T)$ is the price at t of a discount bond maturing at T. Here, $\hat{i}_t$ denotes the path of the short-term interest rate in the future, E_t^Q is the expectations operator under the Martingale measure (that is, the risk-neutral measure), and the circumflexes (^) on the stochastic variables hereinafter mean that these variables are defined under the Martingale measure. The stochastic process for $\hat{i}_t$ is determined by the macro model composed of equations (1)-(8) under the Martingale measure.

The macro model is driven by the demand and supply shocks, which can be represented as stochastic processes by transforming equations (7) and (8) as follows.

$$d\varepsilon_t^d = -(1-\rho_d)\varepsilon_t^d dt + \sigma_d dB_t^d, \quad \rho_d = -0.003, \quad \sigma_d = 0.722, \tag{10}$$

$$d\varepsilon_t^s = -(1-\rho_s)\varepsilon_t^s dt + \sigma_s dB_t^s, \quad \rho_s = 0.060, \quad \sigma_s = 0.417, \tag{11}$$

[13] For the period without the ZIRP/RZIRP, only the market prices of risk are estimated from the yield curve observed in the market and used for the simulation explained in this subsection.

where dB_t^d and dB_t^s denote the increments of standard Brownian motion. Based on the no-arbitrage pricing theory,[14] these stochastic processes are transformed into risk-neutral processes, as below, to calculate expectations in equation (9).

$$d\hat{\varepsilon}_t^d = [-(1-\rho_d)\hat{\varepsilon}_t^d - \lambda^d \sigma_d]dt + \sigma_d d\hat{B}_t^d, \tag{12}$$

$$d\hat{\varepsilon}_t^s = [-(1-\rho_s)\hat{\varepsilon}_t^s - \lambda^s \sigma_s]dt + \sigma_s d\hat{B}_t^s, \tag{13}$$

where λ^d and λ^s denote the market prices of risk regarding the demand and supply shock, respectively. Given the threshold rate, the market prices of risk, and the initial value of endogenous economic variables, we can calculate equation (9) numerically. That is, we conduct Monte-Carlo simulations to derive the future paths of the output gap, inflation, and the short-term interest rate under the Martingale measure, starting from the initial state of the economy at the time of observation.[15,16] This leads to a model-based yield curve. Macroeconomic data used as initial values are presented in **Figures 3, 4, and 5**.

We then estimate the threshold rate (x_t) and the market prices of risk (λ_t^d, λ_t^s) for each quarter (t) such that the model-based yield curve (R_t^T) best fits the yield curve ($\overline{R}_t^T$) observed in the market.[17] Specifically, we search for the values that minimize the sum of the square errors at 20 grid points (denoted by i below), set at every other quarter (i.e., every six months) on the yield curve, between the two curves. This optimization problem is presented as follows.[18]

$$\min_{\{x_t, \lambda_t^d, \lambda_t^s\}} \sum_{i=1}^{20} (R_t^{2\cdot i} - \overline{R}_t^{2\cdot i})^2 . \tag{14}$$

Once we find the optimal value of the threshold rate, we derive the expectations component of medium- to long-term interest rates by calculating equation (9) under

[14] Examples of standard literature on this issue are Duffie (2001) and Hull (2001).

[15] We cannot calculate this analytically since the policy rule includes nonlinearity due to the zero rate commitment and the zero lower bound constraint.

[16] Each simulation is conducted 1,000 times; that is, a thousand paths are used to calculate the expected value in equation (9). For the simulations, the natural rate of interest in the future is set at a constant 1.05%. This value is the average of the past natural rate in the period from 1995 to 2003, during which the natural rate was stable; thus the value seems plausible as a perceived rate for the future.

[17] The observed yield curve is derived for the maturity of zero to ten years by McCulloch's (1971) method from the price data of all JGBs outstanding.

[18] For this optimization, we adopted the Downhill Simplex method.

subjective probability, not under the Martingale measure, with a Monte-Carlo simulation, whereby the threshold rate is set at the optimal value and both market prices of risk are set at zero. We obtain the risk premium component of the medium- to long-term interest rates by subtracting the expectations component from the model-based interest rate.

4. Analysis of the Zero Interest Rate Commitment and its Effects on Medium- to Long-Term Interest Rates

In this section, we show the results of decomposing the medium- to long-term interest rates in Japan into two components for the period of 1995/Q1-2003/Q4, and the results of estimating the threshold rate of inflation for the period during which the zero rate commitment is in effect.

4. 1 Expectations and Risk Premium Components of Medium- to Long-Term Interest Rates

Before investigating the effect of the zero rate commitment, let us review the development of medium- to long-term interest rates in Japan since mid 1990's. **Figure 6** shows the estimation results for model-based interest rates, and their expectations components and risk premium components at ten-, five-, and three-year maturities for the period of 1995-2003. **Table 1** shows a summary of **Figure 6**, presenting the development of average interest rates for each of the three time phases; i.e., 1995-97, 1998-2000, and 2001-03. The table and figure indicate the following.

- The average of the interest rate at each maturity decreased phase by phase, as shown in the table, because both expectations and risk premium components decreased.
- Looking at the figure, we see that during the period of 1995-97, the interest rate at each maturity decreased significantly, declining by more than 50% in the three years. This is attributed to the decrease in the risk premium component[19] while the

[19] The reason for such a large decrease in the risk premium component in this period is not explicitly investigated here. One possibility may be the influence of the decrease in overseas long-term interest rates, especially those in the United States, in this period. This would reduce the long-term interest rates in Japan through market arbitrage. Since the structural model in this paper does not take into account such an open economy effect, the expectations component would not change in this case and the risk premium component would be estimated to be reduced. To correct for such a possibility, the IS curve in the model should be modified to an open economy version, one that takes into account the effects of overseas interest rates and

expectations component was increasing gradually in this period, reflecting the economic environment of the time.

- During the period of 1998-2000, the interest rate at each maturity and the associated components were relatively stable.
- At the beginning of the period of 2001-03, when the QMEP was introduced, the interest rate at each maturity and both of the associated components became lower than in the former period. From then until the first half of 2002, the rate and the components were relatively stable. However, in the year from 2002/Q3 to 2003/Q2, the interest rates gradually decreased again, mainly due to the decrease in the risk premium component, reaching historical lows in 2003/Q2, as shown in the table; the risk premium at each maturity also declined to near zero. This was a time of global deflation scare and the rising bond market. Our model may not be adequately capturing such changes in expectations. From 2003/Q2 to 2003/Q4, the interest rates turned upward led by increases in both expectations and risk premium components. The increase in the expectations component seems to correspond to the economic recovery that was taking hold.

4. 2 Perceptions of the Details of the Zero Interest Rate Commitment

Figure 7 presents an estimate of the threshold inflation rate for the period under the ZIRP and RZIRP. While the threshold rate by definition reflects the necessary condition for exiting the ZIRP/RZIRP, this threshold can be interpreted as the perceived degree of monetary easing when the economy is stuck at the zero bound.[20]

Looking at the figure, the characteristics of the estimated threshold inflation rate are summarized as follows.

- During the ZIRP period, the threshold rate was within a relatively low range and decreased over time until the policy was terminated in 2000/Q3. In particular, the threshold rate was nearly zero in the first half of 2000. This is consistent with the comments of some BOJ board members in this period concerning the desirability of discontinuing the ZIRP in the near future.
- During the RZIRP period, the threshold rate was low, in the 0.0%-0.1% range, in the first five quarters after the introduction of the policy. It would appear that this

exchange rates. This remains as an issue for the future.

[20] Oda and Nagahata (2005) adopt a different approach to describing the accommodative monetary policy stance near the zero rate. They use a “nonlinear optimal simple policy rule,” devised by modifying a Taylor-type rule, to describe preemptive monetary easing and compare the effects on social welfare with the effects of policy rules featuring a zero rate commitment.

feature was an extension from the end of the ZIRP period.

- The threshold rate jumped upward in 2002/Q3 and continued to increase until 2003/Q2. As we see in **Figures 4** and **5**, this was a period of gradual economic recovery, and expected future short-term interest rates would have gone up without the RZIRP. However, increases in the expectations component of interest rates were largely contained until 2003/Q2, as shown in **Figure 6**, because of the effect of the RZIRP with a relatively high threshold rate. Thus, the medium to long-term interest rates continued to fall in this period along with a decrease in the risk premium component.

There is more than one possible interpretation of this increase in the threshold rate during 2002/Q3-2003/Q2. While no explicit statements were made during this period to enhance the effectiveness of the commitment, the BOJ had been increasing the target CABs and its outright purchase of JGBs, as shown in **Figures 2** and **12**, which might have had some signaling effects. These hypotheses will be assessed later in subsections 5.1.1 and 5.2.1, respectively. An alternative interpretation is that the market's perception of the economic outlook may have been weaker than assumed in the simulation[21]. This may have resulted in higher estimates of the threshold rate than the market had in fact anticipated.

However, it is not easy to explain why the estimate of the threshold rate remains near 1 percent for the second half of 2003. If anything, the market seems to have become suspicious of the BOJ's intention to continue the RZIRP and pushed up long-term interest rates in the summer of that year. It could be argued, however, that even the seemingly sharp rise in interest rates at the time may have been mild relative to improvements in market expectations and thus could be consistent with a higher threshold rate. In addition, the BOJ responded by clarifying the commitment in October, as described in section 2. These forces may have cancelled each other out, resulting in minor movement in the threshold rate. Still, the estimate of the threshold rate at approximately 1.0 percent seems disproportionately high in light of the current commitment and thus requires explanation.[22]

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[21] We may note that this was a period during which deflation or disinflation was a worldwide threat.

[22] It might be possible that the estimate of the threshold rate is somewhat biased upward for the following reason. In this paper, the monetary policy rule is formulated and estimated as linear, except for the zero rate commitment element. However, in the zone in which the policy rate is close to zero but is positive, the actual policy rule may be more aggressive in the sense of guiding rates to lower levels than the policy rule assumed here. Thus, the actual rule may be nonlinear, being more accommodative and involve an element of preemptive easing. As Oda

4. 3 Effects of the Zero Interest Rate Commitment

To investigate the effects of the zero interest rate commitment for the ZIRP/RZIRP periods, we will derive the hypothetical long-term interest rates and their components that would have obtained if the commitment had not been implemented for the period. Note that we have already derived a model-based yield curve and associated components under the zero rate commitment in subsection 3.2 using Monte-Carlo simulations. Given the market prices of risk estimated by the above simulation, another set of simulations is conducted in a similar way, although based on the structural model with the type 1 policy rule, i.e., on a version without the commitment, instead of on the type 2 rule.

Figure 8 (i)-(iii) presents an estimate of the expectations component of the interest rates at three-, five-, and ten-year maturity for both cases; i.e., under the zero rate commitment and without the commitment. The difference between the two cases can be interpreted as the effect of the zero rate commitment on the interest rates, which is shown in **Figure 8** (iv). Similarly, **Figure 9** (i)-(iii) presents an estimate of the risk premium component for the two cases at each maturity and **Figure 9** (iv) shows the effect of the zero rate commitment.

With reference to **Figure 8**, we find that the estimated expectations component of the interest rates at all maturities are lower in the case of the commitment policy. The differences between the two cases began to increase from 2002/Q3, and expanded sharply in 2003, because the expected future short-term interest rates without the zero rate commitment went up (probably in response to improving economic conditions), while the commitment to a large extent contained the increases. This result is consistent with the findings in subsection 4.2. In general, the ZIRP and RZIRP imply a promise to maintain a zero interest rate, even after the interest rate under the modified Taylor rule rate turns positive, unless the exit condition based on the CPI measure is met. Thus, the difference in expected three-year interest rates, say, between the modified Taylor rule and the ZIRP or RZIRP, is small if the interest rate under the Taylor rule is expected to remain negative for three years or more. The difference becomes larger as

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and Nagahata (2005) point out, the market may have regarded the introduction of the ZIRP and QMEP as a sign of more aggressive policy stance by the BOJ and have changed the perceived policy rule from linear to nonlinear in the neighborhood of a zero rate. Then, interest rates would be lower even without a rise in the threshold rate. Our estimates of the threshold rate, which does not take into account such nonlinearity, would then be higher than the value perceived in the market.

investors start to consider the possibility that the interest rate under the Taylor rule will turn positive within three years but that the exit condition would not yet be met. This may have been the situation in 2003, as can be seen in **Figure 8**. If the expected period during which the commitment will continue to be binding is relatively short, the difference in rates on the three-year horizon will be larger than that on the ten-year horizon, because the commitment is expected to become non-binding as the economy approaches the steady state in the future. This may also have been the situation in 2003 as indicated in Figure 8 (iv).

Figure 9 shows that the effects of the commitment on the risk premium component of interest rates have been limited, with the exception of the period after 2003/Q2, for the three-year interest rate. The effects are almost negligible for the ten-year interest rate. This seems reasonable if the expected duration of a zero interest rate is relatively short. The commitment reduces uncertainties about the duration of a zero interest rate; hence it can contain the risk premium component of the interest rate for relatively short maturities. This could explain the emergence of the difference between the two cases of the three-year rate during 2003/Q2-Q4. Meanwhile, sharp reductions in risk premiums are observed during 2002/Q3-2003/Q1, both with and without the commitment. This may have been due to the stabilization of the inflation rate at low levels in late 2002 and 2003.

5. Regression Analysis of Quantitative Monetary Easing Effects

In this section we report on the results of analyses regarding the various potential effects of the QMEP, other than the "policy duration effect" of the RZIRP already examined, using simple regressions based on the results of section 4. Specifically, we analyze the possibility of policy effects of the expansion of the CAB target and of the BOJ's purchases of JGBs from two perspectives: (i) whether or not the policy has a signaling effect on the perceived details of the zero rate commitment; and (ii) whether or not the policy is capable of reducing the risk premium component of medium- to long-term interest rates.

5. 1 Testing for the Signaling Effect

As we have implicitly assumed in the above analysis, the BOJ's commitment regarding the threshold inflation rate under the type 2 rule has been vague. Under the QMEP, the BOJ effectively promised to keep a zero rate "until core CPI inflation is stably above zero." This statement can be consistent with a fairly wide range of the threshold rate. In October 2003 the statement was revised to read "until at least actual and expected inflation are above zero." The revised statement still contains an element of ambiguity because actual and expected inflation turning positive are only necessary, but not sufficient conditions for an exit. Under such an environment, any policy statement and/or action by the BOJ has the potential of affecting the market's perception of the threshold rate, i.e., may generate signaling effects.

We assume that the expansion of the CAB target and the BOJ's outright purchases of JGBs are possible such signaling actions. We will assess the possibility of the signaling function of these actions by investigating whether or not a given action influenced the commitment effect, defined in subsection 4.3, on the expectations components of interest rates.

Based on this consideration, we regressed the effects of the zero rate commitment, shown in **Figure 8**, on the CABs at the BOJ (**Figure 10**) and the BOJ's purchases of JGBs (**Figure 12** (i)), assuming a disturbance term of AR(1). **Table 2** presents the estimation results. For each of the ten-, five-, and three-year interest rates, the coefficient of the CABs is statistically significant and positive, suggesting a signaling effect, although the estimated value of the coefficient is not large.[23] In contrast, for each interest rate, the coefficient of the BOJ's purchases of JGBs is not necessarily statistically significant and is negative. These results do not change qualitatively even if the regressions are conducted with only one explanatory variable --either the CABs or the BOJ's purchases of JGBs. Thus, the results lead to the tentative conclusion that the expansion of the CABs may have been perceived by the market as indicating a greater willingness on the part of the BOJ to carry out RZIRP.[24]

Other interpretations, however, are possible. One such possibility is that the signal was mainly generated by various types of communication between the BOJ and the market as the CAB target was changed -- for example, the BOJ governor's

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[23] The estimate shows that an increase of ten trillion yen in the CABs at the BOJ is likely to lower the ten-, five-, and three-year interest rate by 0.11%, 0.17%, and 0.19%, respectively.

[24] It is somewhat dangerous to read too much into this result. Whether or not a change in the CAB target has such a signaling effect depends on the degree of the public's understanding of monetary policy in the zero rate environment. In general, the more uncertain the public is on the policy stance, as in the early period of the ZIRP and RZIRP, the larger is the signaling effect caused by a policy action of a central bank. Thus, the record of signaling in the past may not necessarily suggest the possibility of signaling in a similar magnitude in the future. Especially, when the public becomes certain about the policy stance, the change in the CAB target may have no signaling effect.

comments at regular press conferences and the issuance of BOJ's formal documents, such as "The Enhancement of Monetary Policy Transparency" in October 2003 -- rather than being generated by the changes in the CAB itself. It remains to be seen whether or not the above tentative conclusion will still stand in analysis using a larger data set and a model with more explanatory variables relating to this alternative interpretation.

5. 2 Testing for the Effect on the Risk Premium of Interest Rates

Finally, we estimate two sets of equations regarding the possible effects of the expansion of the CABs and the BOJ's outright purchases of JGBs on the risk premium.

First, we regressed the risk premium components of medium- to long-term interest rates, shown in **Figure 6**, on the CABs (**Figure 10**) and the share of JGBs held by the BOJ in total JGBs outstanding (**Figure 12** (ii)) along with two other variables and a constant, assuming an AR(1) structure for the disturbance term. This was to determine whether or not such BOJ's open market operations eased the demand-supply balance in the bond market or other non-monetary assets and, as a result, lowered the risk premium through the portfolio rebalancing effect. We included the CABs in the regression since their expansion has been accompanied by increases in various open market operations,[25] which may have affected the risk premium through portfolio rebalancing by market participants. The explanatory variables included the turnover rate of JGBs (**Figure 11** (i)), as a measure of the liquidity premium,[26] and the spread between TB and the banks' CD rates (**Figure 11** (ii)), as a proxy for 'flight to quality' effects.

Table 3 presents the results of the regression. With respect to the coefficient of the CABs, the estimate for the ten-year interest rate is negative, suggesting the portfolio rebalancing effect, but is statistically insignificant while the coefficient estimates are positive for the five- and three-year rates. With respect to the coefficient of the BOJ's share of JGBs, the estimate for each rate is positive and statistically insignificant. Therefore, it seems that the portfolio rebalancing initiated by the BOJ's open market operations of non-monetary assets thus far has had no statistically significant effect on reducing the risk premium of medium- to long-term interest rates. These results do not change qualitatively even if the regressions are conducted by omitting either the CABs

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[25] In order to meet the CAB target the BOJ has conducted various purchasing operations, including the acquisition of bills and commercial papers (CPs) in addition to treasury bills (TBs) and government bonds (JGBs). In 2003 the BOJ also began buying asset-backed commercial papers (ABCPs) and asset-backed securities (ABSs).

[26] The higher the turnover rate of JGBs, the more liquid the JGB market is and the smaller liquidity premium is in the interest rates on JGBs.

or the BOJ's share of JGBs.

Second, we regressed the risk premium components on the CABs and the flow amount of the BOJ's outright purchases of JGBs in each quarter (**Figure 12** (i)) along with the same two other variables as above and a constant, assuming again an AR(1) structure for the disturbance term. This was to evaluate the hypothesis that the increase in the CAB target or in the BOJ's purchase of JGBs strengthened the market's confidence on the BOJ's accommodative policy stance, and thus reduced the uncertainty as to the future policy path, leading to a reduction in the risk premium. As shown in **Table 4**, however, all the coefficients of the CABs and the BOJ's purchases of JGBs were statistically insignificant at all maturities. Therefore, it appears that the increase in these variables has had no statistically significant effect to reduce the risk premium for medium- to long-term interest rates.

6. Concluding Remarks: Summary of Findings and Further Issues

We have examined empirically the effects of the ZIRP and QMEP in Japan on medium- to long-term interest rates using a macro-finance model. We tentatively conclude that the BOJ's monetary policy under the zero interest rate environment since 1999 has functioned mainly through the zero rate commitment, which has led to reduced medium- to long-term interest rates. More specifically, the commitment has been effective in lowering the expectations component of interest rates, especially with short- to medium-term maturities, while it has been less effective in lowering the risk premium component. In contrast, the portfolio rebalancing effect -- either by the BOJ's supplying liquidity beyond the required level to keep the short-term policy rate at virtually zero (i.e. the expansion of the CAB at the BOJ) or by the BOJ's purchases of JGBs-- on the risk premium component of the interest rates has not been found significant. There is some evidence that raising the target for the CABs has been perceived by the market as a signal indicating the BOJ's greater willingness to carry on RZIRP and has thus enhanced the effects of the zero rate commitment, although this interpretation is subject to further examination.

Several issues remain for further study in connection with this analysis. Among these is the desirability of extending the sample period for analysis This could enable verification of the robustness of our tentative conclusions, especially those of section 5, and to choose the correct interpretation for the regression results from among the alternatives put forward. Regarding the structural model of the economy, three interesting challenges remain. The first challenge is to construct an open economy version of the model, since the long-term interest rates in Japan can be affected by exchange rates or overseas interest rates, especially those in the United States. The second is to take into account the possible effect of the risk premium component of the interest rates on aggregate demand, although it may be difficult to overcome the burden of recursive calculation in such a case. The last challenge is to make the model forward-looking. Meeting these challenges will surely enhance our understanding of the macroeconomic effects of the types of policy the BOJ has adopted.

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Table 1: Component Decomposition of Medium- to Long-Term Interest Rates

—— Summary of the estimation results presented in Figure 6

(%)

	1995/Q1 -1997/Q4 average	1998/Q1 -2000/Q4 average	2001/Q1 -2003/Q4 average	2003/Q2	2003/Q4
CPI (excluding fresh food), y/y chg.	0.29	-0.14	-0.66	-0.40	0.00
Ten-year interest rate (model-based)	3.32	1.91	1.33	0.64	1.53
Expectations components	1.23	0.69	0.51	0.66	0.89
Risk premium components	2.10	1.21	0.82	-0.03	0.65
Five-year interest rate (model-based)	2.14	1.02	0.48	0.24	0.69
Expectations components	1.00	0.41	0.22	0.28	0.44
Risk premium components	1.13	0.61	0.26	-0.03	0.25
Three-year interest rate (model-based)	1.57	0.61	0.18	0.08	0.29
Expectations components	0.88	0.26	0.09	0.10	0.19
Risk premium components	0.69	0.35	0.09	-0.02	0.10

Table 2: Regression of the Commitment Effect on the BOJ's Current Account Balance and Purchase of JGBs

Regression Method: Maximum Likelihood with AR(1)

Period: 1995/Q1-2003/Q4

	Effects of the zero rate commitment in the expectations components		
	10-year	5-year	3-year
BOJ’s current account balance	<u>0.011</u>	<u>0.017</u>	<u>0.019</u>
Standard error	*0.001*	*0.003*	*0.004*
P-value	<u>*0.00*</u>	<u>*0.00*</u>	<u>*0.00*</u>
BOJ’s purchase of JGBs	<u>-0.023</u>	<u>-0.031</u>	<u>-0.034</u>
Standard error	*0.012*	*0.017*	*0.019*
P-value	<u>*0.06*</u>	<u>*0.07*</u>	<u>*0.09*</u>
Constant	-0.01	-0.03	-0.03
Standard error	*0.02*	*0.05*	*0.06*
P-value	*0.63*	*0.57*	*0.63*
AR(1)	0.70	0.82	0.85
Standard error	*0.16*	*0.15*	*0.15*
P-value	*0.00*	*0.00*	*0.00*
Adjusted-R^2	0.91	0.91	0.90
Std. err. of equation	0.02	0.03	0.03
D.W. ratio	1.86	1.60	1.34

Note : The dependent variable is defined as the difference between the expectations components with and without the zero rate commitment.

Table 3: Regression of the Risk Premium Component on the BOJ's Current Account Balance and Share of JGBs

Regression Method: Maximum Likelihood with AR(1)

Period: 1995/Q1-2003/Q4

	Risk premium components		
	10-year	5-year	3-year
BOJ's current account balance	-0.016	0.003	0.008
Standard error	*0.01*	*0.01*	*0.01*
P-value	*0.23*	*0.72*	*0.30*
BOJ's share of JGBs	0.020	0.065	0.061
Standard error	*0.07*	*0.04*	*0.04*
P-value	*0.76*	*0.14*	*0.13*
Turnover rate of JGBs	-0.19	-0.17	-0.14
Standard error	*0.08*	*0.06*	*0.05*
P-value	*0.02*	*0.01*	*0.01*
Spread between TB and CD	0.59	0.11	-0.04
Standard error	*0.58*	*0.43*	*0.38*
P-value	*0.32*	*0.81*	*0.92*
Constant	2.00	0.13	-0.26
Standard error	*1.27*	*0.83*	*0.75*
P-value	*0.13*	*0.87*	*0.73*
AR(1)	0.40	0.26	0.29
Standard error	*0.16*	*0.15*	*0.16*
P-value	*0.02*	*0.11*	*0.08*
Adjusted-R^2	0.55	0.40	0.33
Std. err. of equation	0.28	0.21	0.18
D.W. ratio	2.38	2.12	1.82

Note : Regression results for 5- and 3-year rates remain statistically insignificant on the BOJ's CAB and share of JGBs, even excluding the turnover rate or the TB-CD spread from explanatory variables. There is an exception for 10-year rate in that the result of regression without the turnover rate shows that the coefficient of the BOJ's CAB is statistically significant (p-value = 0.03), although the estimate may be biased due to omitting the turnover rate, which is a statistically significant explanatory variable in the above table.

Table 4: Regression of the Risk Premium Component on the BOJ's Current Account Balance and Purchase of JGBs

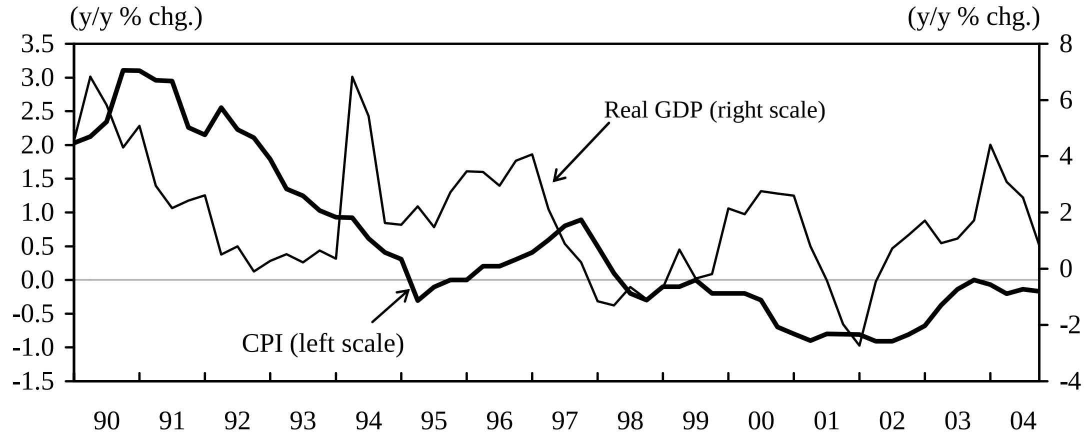
Regression Method: Maximum Likelihood with AR(1)
Period: 1995/Q1-2003/Q4

	Risk premium components		
	10-year	5-year	3-year
BOJ's current account balance	-0.009	-0.005	-0.005
Standard error	*0.03*	*0.02*	*0.02*
P-value	*0.72*	*0.81*	*0.79*
BOJ's purchase of JGBs	-0.077	0.025	0.066
Standard error	*0.21*	*0.16*	*0.15*
P-value	*0.72*	*0.88*	*0.65*
Turnover rate of JGBs	-0.20	-0.16	-0.13
Standard error	*0.08*	*0.06*	*0.05*
P-value	*0.02*	*0.01*	*0.03*
Spread between TB and CD	0.51	-0.11	-0.20
Standard error	*0.55*	*0.42*	*0.38*
P-value	*0.37*	*0.79*	*0.59*
Constant	2.45	1.29	0.78
Standard error	*0.49*	*0.38*	*0.34*
P-value	*0.00*	*0.00*	*0.03*
AR(1)	0.39	0.29	0.33
Standard error	*0.16*	*0.16*	*0.17*
P-value	*0.02*	*0.08*	*0.06*
Adjusted-R^2	0.55	0.34	0.26
Std. err. of equation	0.27	0.22	0.19
D.W. ratio	2.35	1.99	1.73

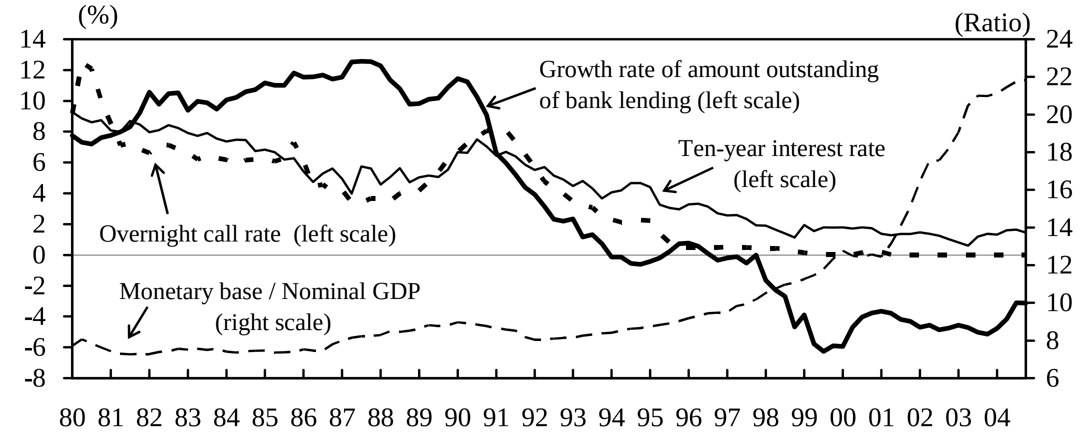
Note : Regression results for 10-, 5-, and 3-year rates remain statistically insignificant on the BOJ's CAB and purchase of JGBs, even excluding the turnover rate or the TB-CD spread from explanatory variables.

Figure 1: Monetary Indicators, Economic Activity, and Price Development in Japan

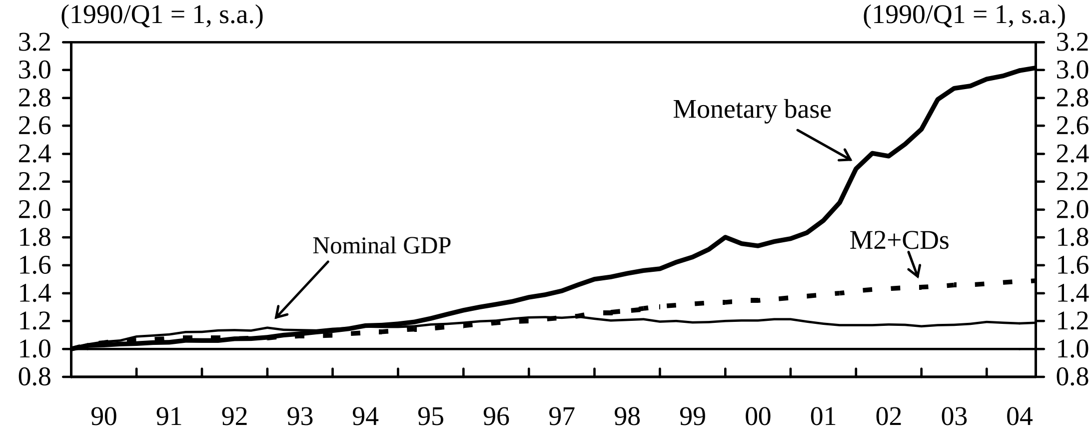
(i) Real GDP and CPI



(ii) Interest rates, monetary base, and bank lending

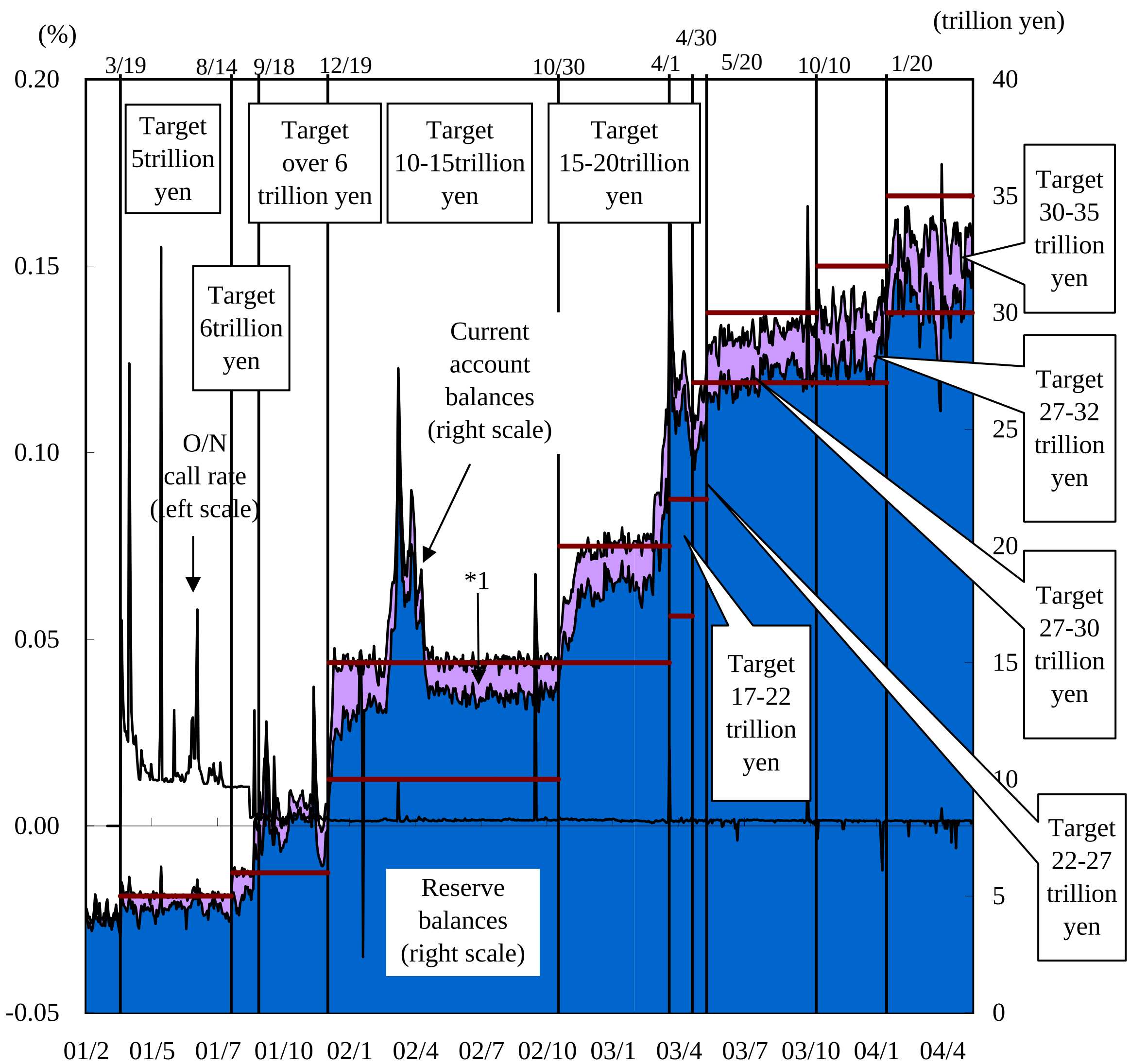


(iii) Monetary base, money supply, and nominal GDP



Source: Bank of Japan, Cabinet Office, Ministry of Internal Affairs and Communications.

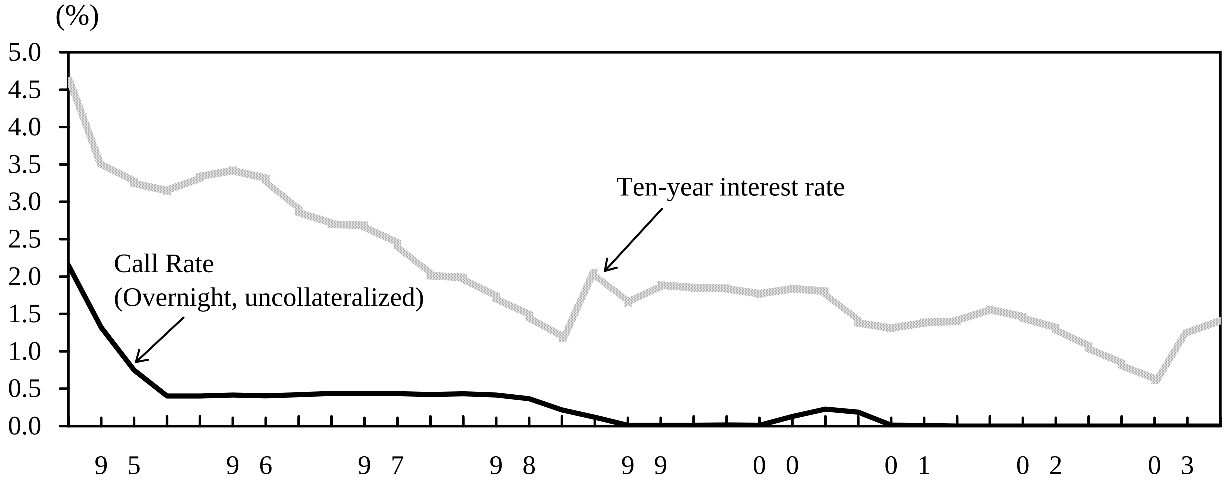
Figure 2: Target Reserve and Actual Balance under the Quantitative Monetary Easing



Note :*1: Current account balances held by institutions that not subject to reserve requirements.

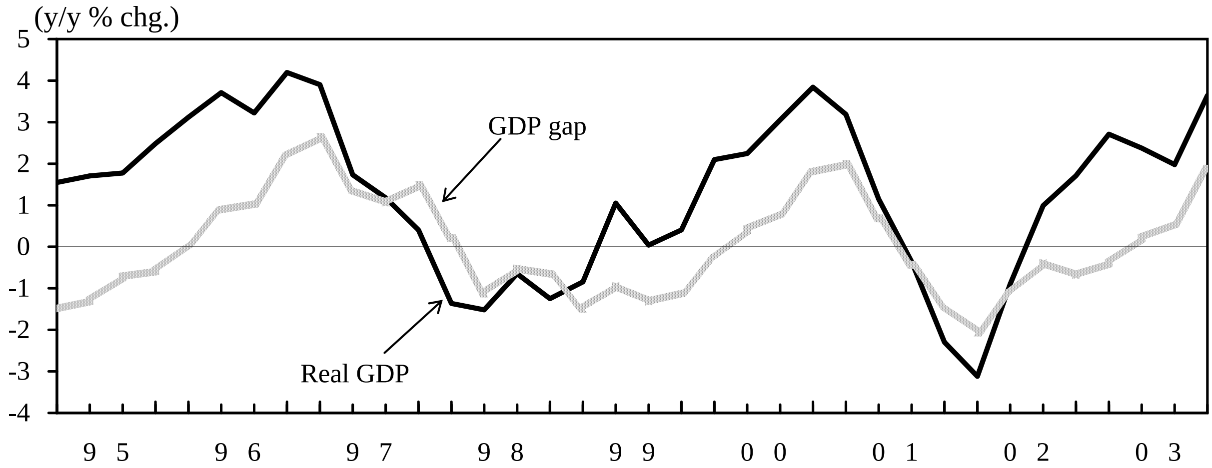
Source : Bank of Japan.

Figure 3: Short / Long-Term Interest Rates



Note : Ten-year interest rate is the yield that is derived based on McCulloch's (1971) method.
Source : Bank of Japan.

Figure 4: Real GDP and GDP Gap



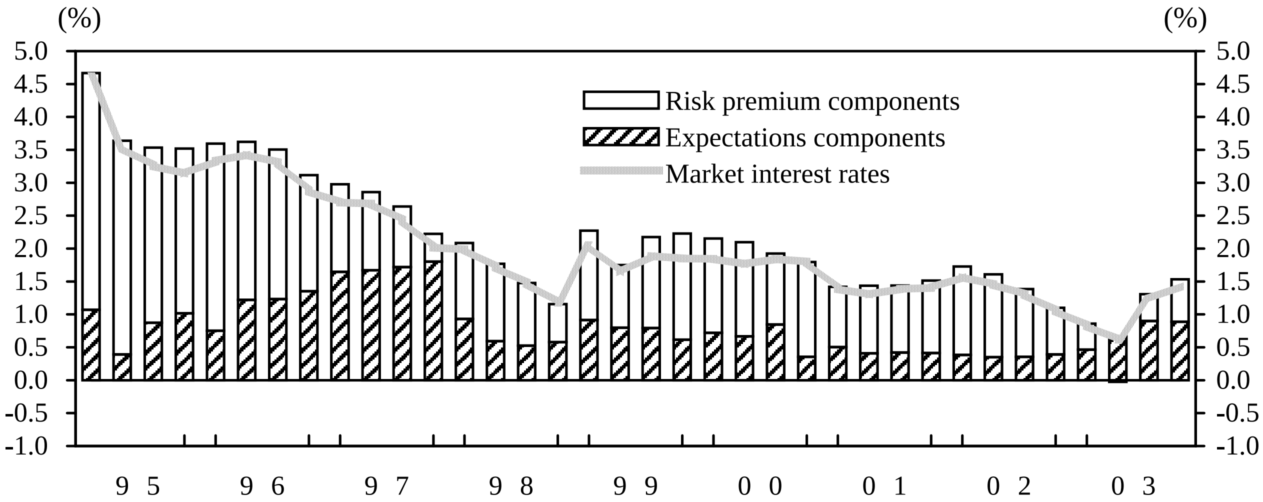
Note : GDP gap is defined as a percentage deviation of the real GDP from the HP-filtered real GDP.
Source : Cabinet Office.

Figure 5: Consumer Price Index (excluding fresh food)

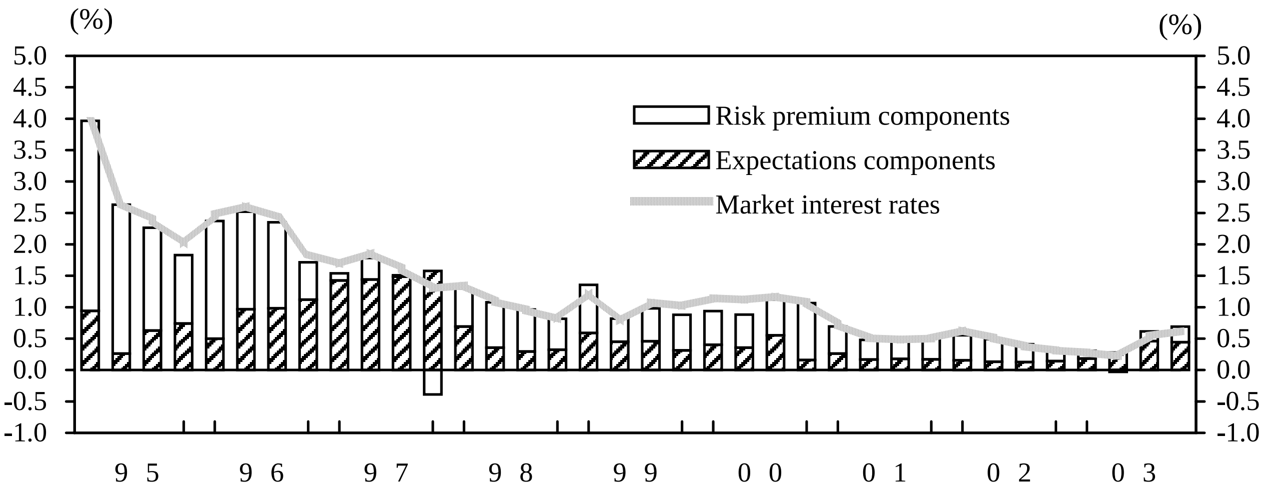
Note : Adjusted to exclude the effects of the consumption tax hike on the assumption that prices of all taxable goods fully reflect the rise in the tax rate.
Source : Ministry of Internal Affairs and Communications.

Figure 6: Estimation of Expectations and Risk Premium Components of Medium / Long-term Interest Rates

(i) Ten-year interest rate



(ii) Five-year interest rate



(iii) Three-year interest rate

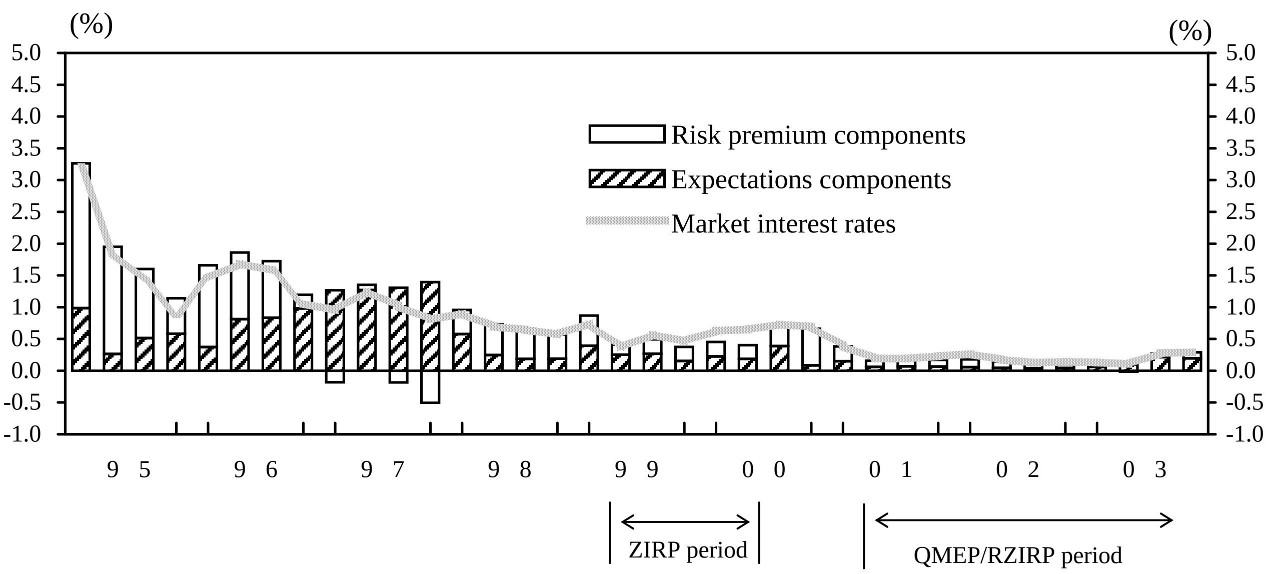


Figure 7: Estimated Value of the Threshold Inflation Rate

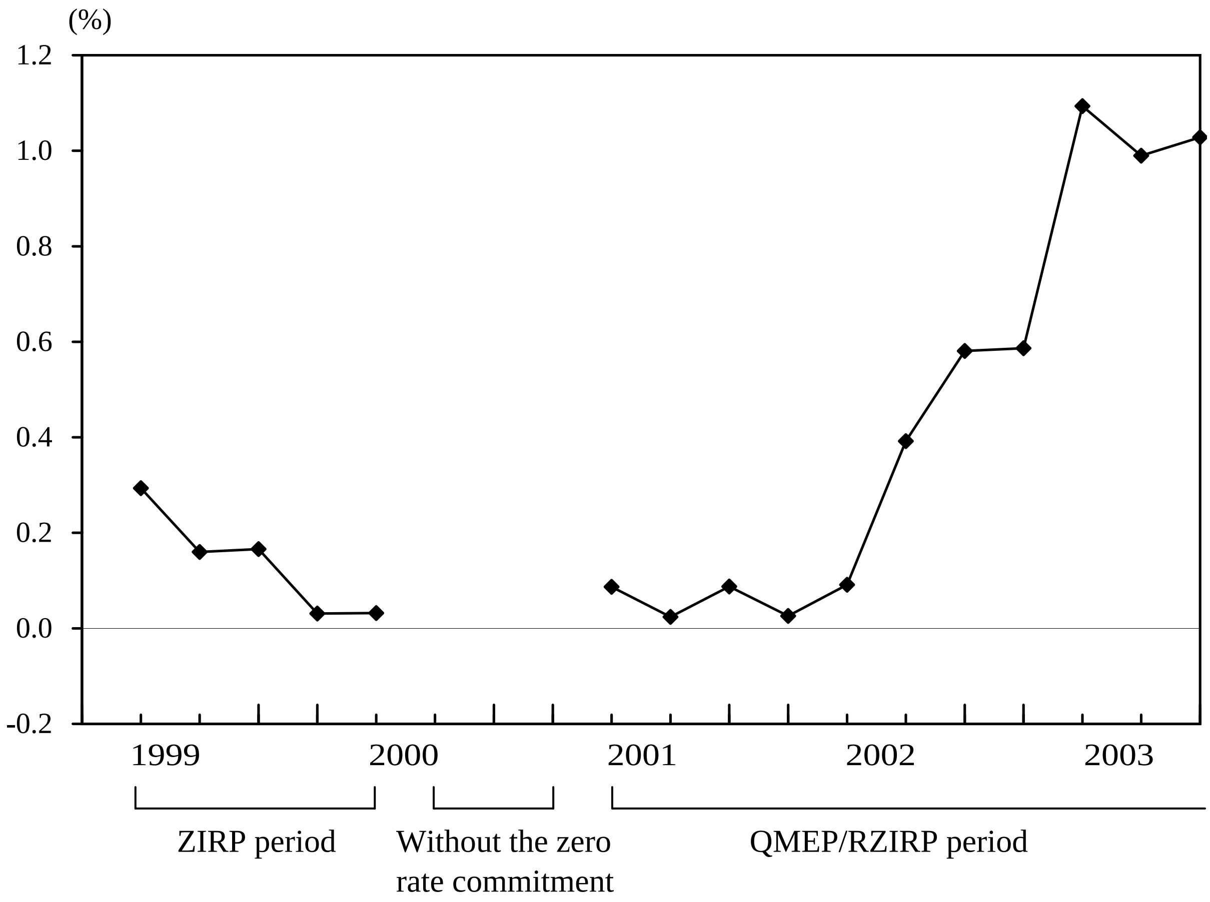
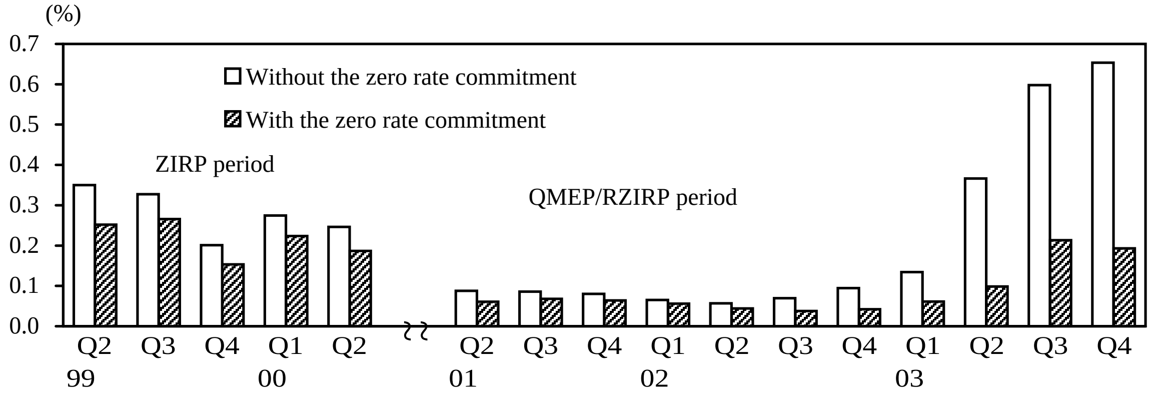


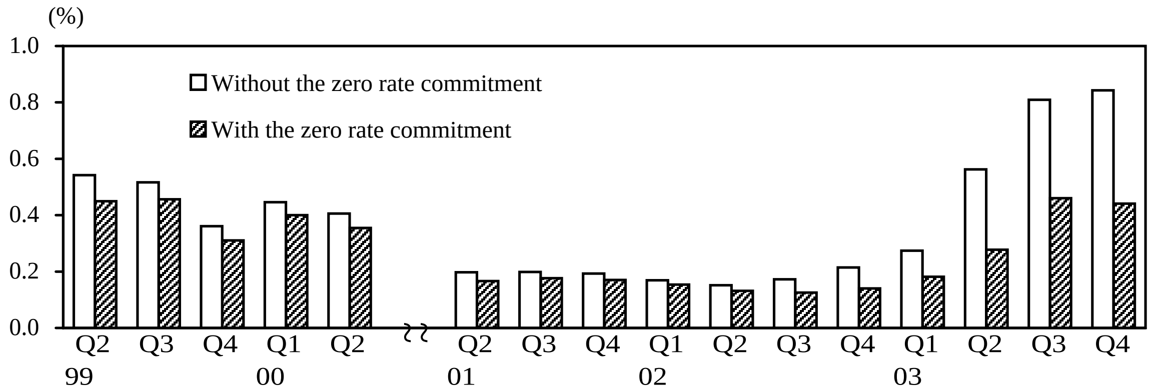
Figure 8: Expectations Components of Medium / Long-term Interest Rates

－Effects of the Zero Rate Commitment－

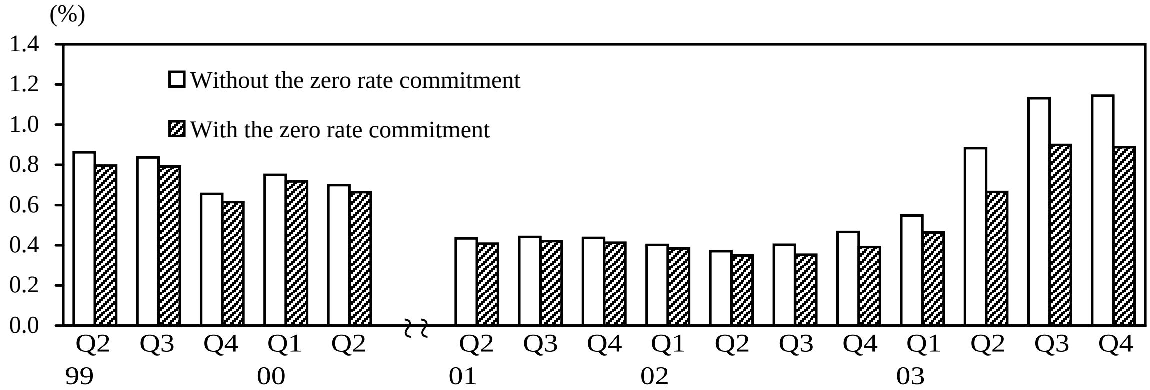
(i) Three-year interest rate



(ii) Five-year interest rate



(iii) Ten-year interest rate



(iv) Effects of the zero rate commitment

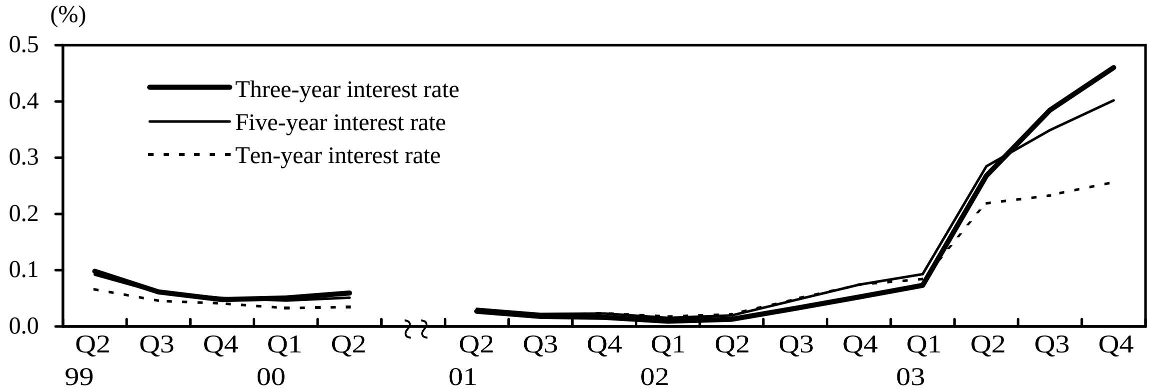
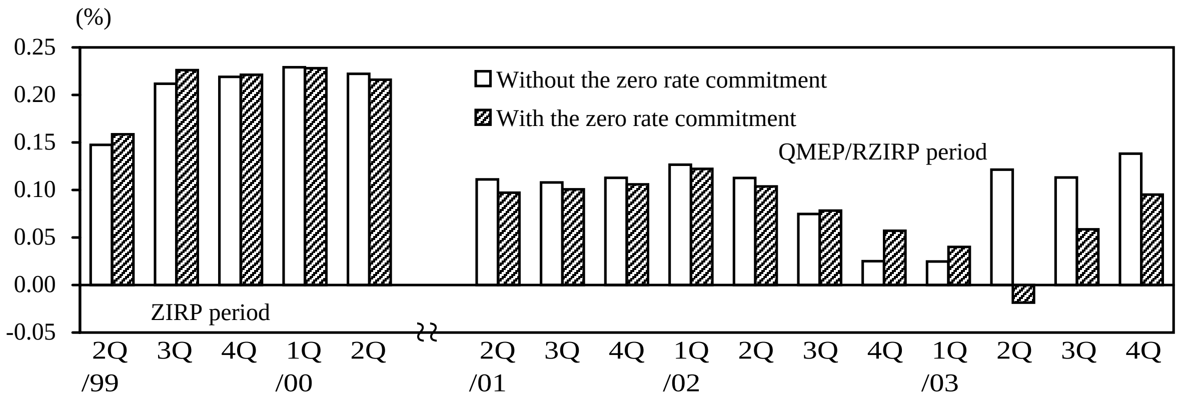


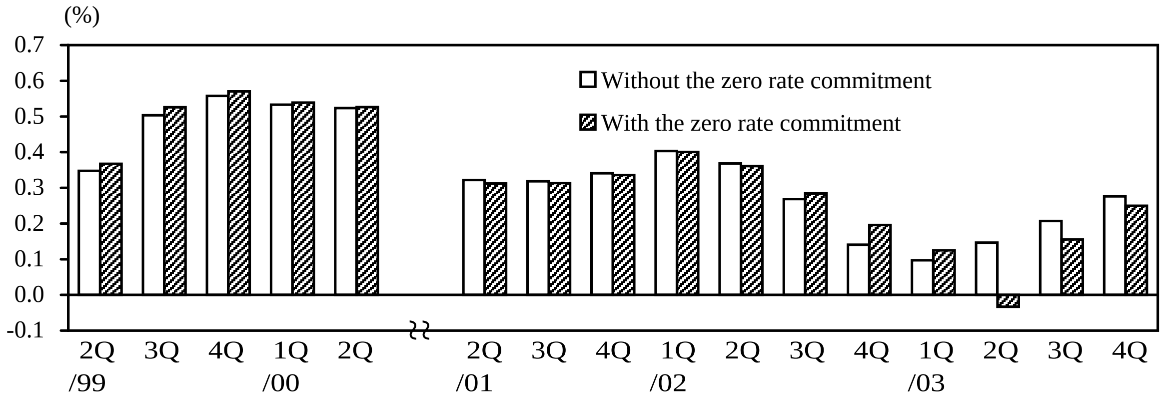
Figure 9: Risk Premium Components of Medium / Long-term Interest Rates

― Effects of the Zero Rate Commitment ―

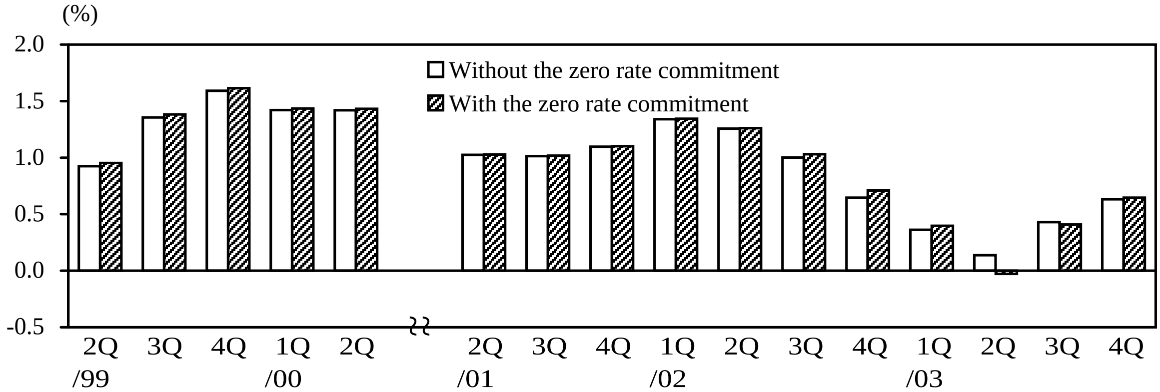
(i) Three-year interest rate



(ii) Five-year interest rate



(iii) Ten-year interest rate



(iv) Effects of the zero rate commitment

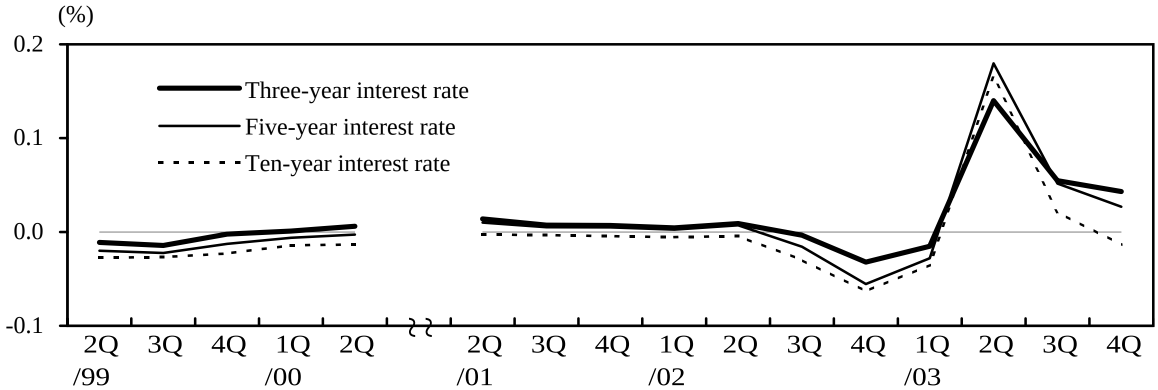
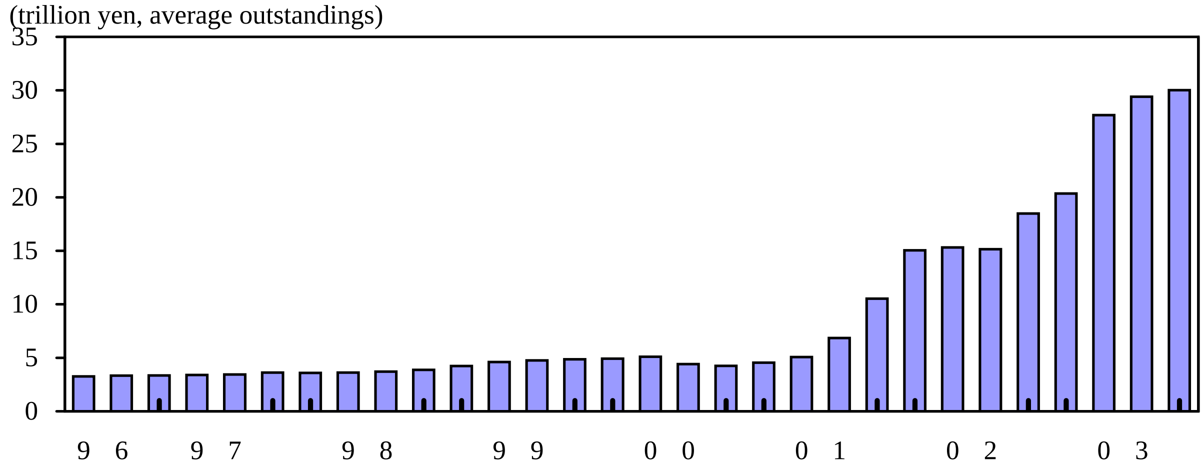


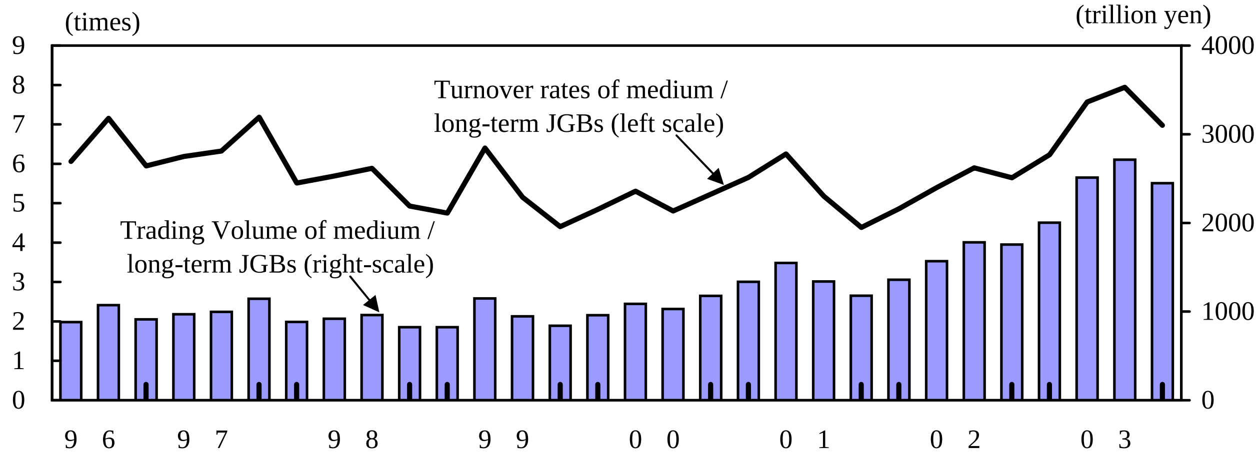
Figure 10: BOJ Current Account Balance



Note : Adjusted to exclude the effects of Y2K and semiannual book closings.
Source : Bank of Japan.

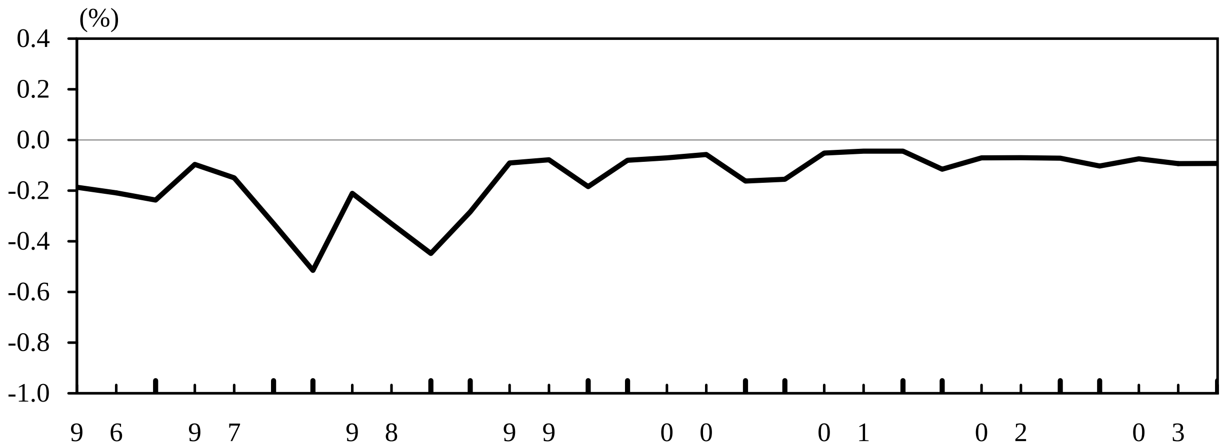
Figure 11: Control Variables of the Regression on Risk Premium Components

(i) Turnover Rate of Japanese Government Bonds



Source : Japan Securities Dealers Association.

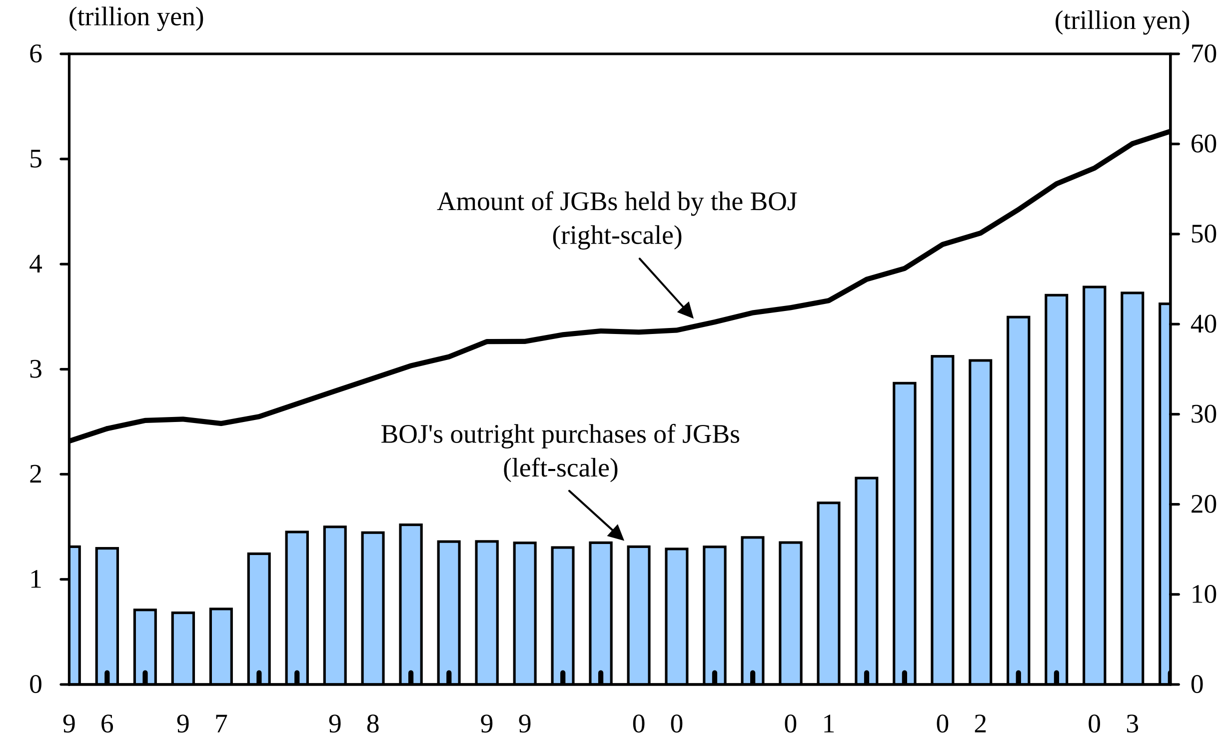
(ii) Spread between TB and Bank's CD Rates (TB-CD)



Source : Japan Bond Trading Company.

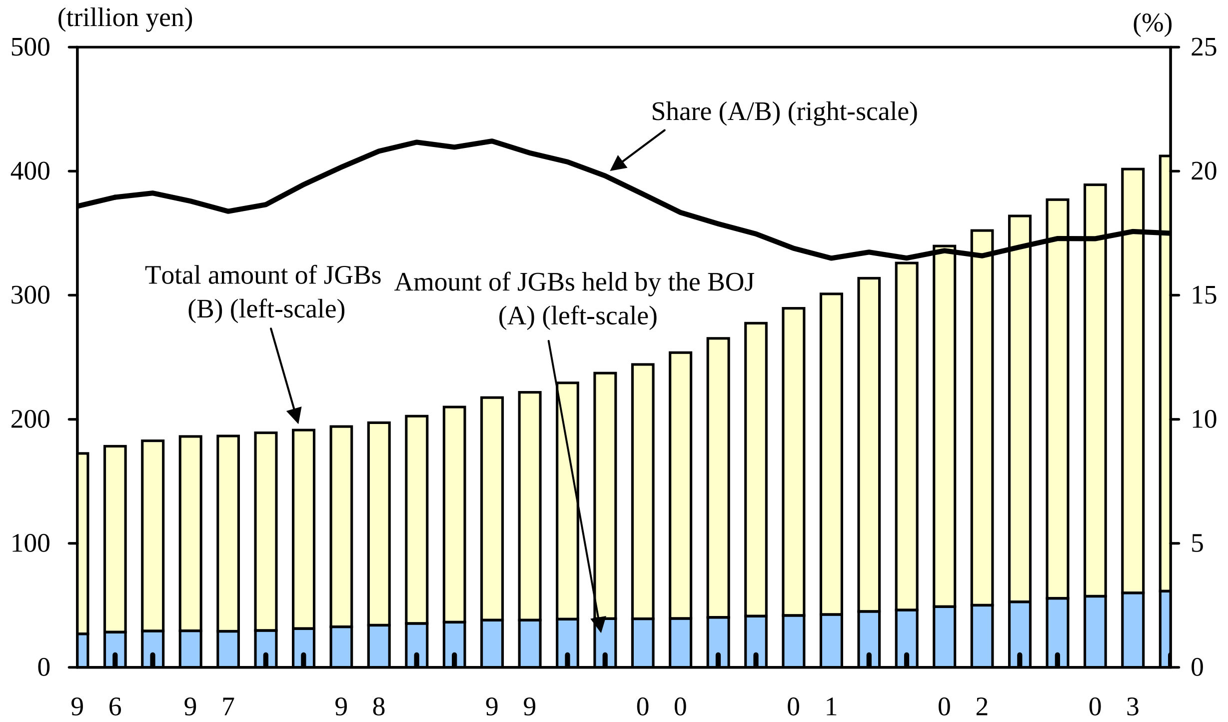
Figure 12: BOJ's Transactions of Japanese Government Bonds

(i) BOJ's Transactions of Medium / Long-Term JGBs: Flow and Stock



Source : Bank of Japan.

(ii) Share of Medium / Long-term JGBs Held by the BOJ in the Total Amount Outstanding



Source : Bank of Japan, Japan Securities Dealers Association.