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Policy Commitment and Market Expectations: Lessons Learned from Survey Based Evidence under Japan's Quantitative Easing Policy

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Abstract

The Bank of Japan conducted its quantitative easing policy (QEP) from 2001 to 2006, with the policy commitment to maintaining its QEP until the CPI inflation rate became stably zero or higher. We evaluate its effects by using individual survey data on inflation expectations as well as interest rate expectations. Our analysis reveals a kinked relationship between interest rate expectations and inflation rate expectations at around the zero percent threshold level of inflation expectations, in tune with this policy commitment. In addition, we evaluate the effects of the policy commitment on market expectations for the future path of short-term interest rates after the termination of the QEP. We find that, even when inflation expectations exceeded the threshold, interest rate expectations responded only gradually to inflation rate expectations.

Keywords: Commitment policy; policy duration effect; unconventional monetary policy; zero lower bound

JEL classification: C23, C24, E43, E44, E52, E58

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1 Introduction

The Bank of Japan (BOJ) conducted its quantitative easing policy (QEP), with a policy commitment, from March 2001 to March 2006 under the zero lower bound (ZLB) on nominal interest rates. The BOJ promised to maintain the QEP until the core CPI inflation rate became stably zero or higher. Moreover, from 2005, the BOJ announced that, after its exit from the QEP, monetary policy would continue to maintain very low short-term interest rates, with gradual adjustments in their level in view of economic and financial developments. Although this type of policy commitment was unprecedented at that time, other central banks such as Bank of Canada and Riksbank introduced similar policy commitment in response to the recent global financial crisis.[1]

In this paper, we evaluate the effects of the BOJ's policy commitment on market participants' interest rate expectations. To this end, we use a rich individual survey source, QSS (QUICK Survey System), provided by QUICK corporation. The survey asks market participants about their views on the future course of interest rates and inflation rates. The effects of the policy commitment need to be examined against developments in expectations regarding not just interest rates but also inflation rates. In particular, the latter data are valuable, because otherwise it is difficult to identify whether low interest rate expectations are due to the policy commitment or simply due to low inflation expectations. In that respect, the QSS provides useful information to analyze the role of the policy commitment.

Our analysis reveals a kinked relationship between interest rate expectations and inflation rate expectations at the threshold level of inflation rate expectations, in tune with the necessary condition for the termination of the QEP. We evaluate the effects of the policy commitment on market expectations not just for the timing of the termination of the QEP but also for the future path of short-term interest rates after the termination of the QEP. Two empirical findings emerge.

First, when inflation expectations remained below the threshold, interest rate expectations

[1] In April 2009, Bank of Canada introduced a conditional commitment, stating "Conditional on the outlook for inflation, the target overnight rate can be expected to remain at its current level until the end of the second quarter of 2010 in order to achieve the inflation target. The Bank will continue to provide such guidance in its scheduled interest rate announcements as long as the overnight rate is at the effective lower bound."

Riksbank regularly announces their inflation and policy rate forecasts. By showing low levels of inflation and policy rate forecasts, it helped lower expectations on the future path of interest rates.

Although their commitment is less clear, the Federal Reserve stated "the Committee believes that policy accommodation can be maintained for a considerable period" in August 2003. The Federal Reserve also announced that they would maintain "exceptionally low levels for the federal funds rate for some time (or an extended period)" from 2008 to 2011.

did not respond to changes in inflation rate expectations. Market participants anticipated the continuation of the QEP and the unchanged low interest rate. The threshold was estimated at around zero percent for three-month TIBOR and two- and five-year government bonds. That level was consistent with the BOJ's policy commitment to continuing the QEP until the CPI inflation rate became stably zero or higher. For long-term interest rates, the kink was unclear.

Second, when inflation expectations exceeded the threshold, interest rate expectations responded to inflation rate expectations, but only modestly. Above the threshold, market participants anticipated an exit from the QEP and rises in the call rate. At the same time, they also anticipated that such adjustments in the call rate would be carried out in a very gradual manner. More precisely, for three-month TIBOR, the estimated size of the jump in the call rate at the threshold was insignificantly small. In addition, the estimated slope of interest rate expectations with respect to inflation expectations was smaller than one. Such responses were consistent with the BOJ's announcement that monetary policy would continue to maintain very low short-term interest rates for some time after the exit from the QEP. For two- and five-year government bonds, the estimated size of the jump in the call rate became about 0.2 percent point and significant, suggesting that market participants took rises in the call rate as a more likely event over two- to five-year horizons.

Using different samples, we deepen analyses on the effects of this policy commitment. We find that market expectations for interest rates during the QEP were lower than those after the QEP, after controlling the level of inflation expectations. This difference amounted to about 0.7 percent point for three-month TIBOR. Expectations for interest rates were more closely linked to expectations for inflation rates during the QEP than after the QEP. That suggests that market participants paid more attention to the developments in inflation rates during the QEP, compared with the period after the QEP. Dividing samples during the QEP, we find that, as the actual CPI inflation increased to the threshold, market participants became more mindful of the termination of the QEP, making their expectations for interest rates more closely linked to expectations for inflation rates. That suggests that the policy commitment effect on market expectations becomes stronger as the economy recovers, which is consistent with views expressed by Shirakawa (2010).[2]

A number of empirical studies exist regarding the effects of policy commitment. As for Japan's QEP, Ugai (2007) provides a survey and concludes that this policy commitment has a clear effect on reducing the future path of interest rates at short- to medium-term maturities.[3]

[2]Shirakawa (2010) argues "the policy duration effect could exert significant easing effects, especially when economic recovery progresses and corporate profits improve."

[3]Regarding other aspects in the QEP, Ugai argues, first, that there were phases in which the increase in the current account balances held by financial institutions at the BOJ bolstered people's expectations. Second,

For example, Baba et al. (2005) develop a macro-finance model to calculate the difference of the future path of interest rates with and without the policy commitment. The difference is as much as 0.4 to 0.5 percent point for three- and five-year government bonds, suggesting a reduction in the yield curve by the policy commitment. The difference is not as large for ten-year government bonds. Baba et al. (2005) and Oda and Ueda (2007) search for the CPI inflation threshold that the BOJ judges as necessary to terminate the QEP. They report that the threshold inflation rate was about one percent; market participants expected that as long the CPI inflation rate was below one percent, the BOJ would continue its QEP. Those results are not remote from ours, but the estimated threshold is higher, suggesting longer persistence of the QEP. Such a difference is attributed to the identification of inflation expectations. As stated above, the low yield curve can arise from low inflation expectations, leading to overestimation of the effects of the policy commitment unless we control inflation expectations. Thanks to the QSS, we overcome such a difficulty, and in turn, obtain relatively smaller effects on the threshold.

As for the policy commitment by the Bank of Canada, Chehal and Trehan (2009) and He (2010) report opposing results. Chehal and Trehan (2009) argue that the policy commitment did not have persistent effects on interest rates. He (2010) argues that the policy commitment lowered the interest rate for two-, five-, and ten-year government bonds, although his result is not statistically strong. Similar to Japan's existing studies, those two studies use aggregate variables only. Changes in inflation expectations are not sufficiently taken into account to identify policy effects.

This paper is structured as follows. In Section 2, we provide the simple model of the policy commitment and discuss our estimation strategy. In Section 3, we explain the QSS and estimate the effects of the policy commitment. In Section 4, we provide concluding remarks.

2 Model

2.1 Overview of the Policy Commitment

Facing the prolonged stagnation following the burst of the asset price bubble in the early 1990s, the BOJ lowered its policy rates to reach the zero lower bound (ZLB) of nominal interest rates (Figure 1) and adopted a series of unprecedented policies. Among many, one notable policy adopted in March 2001 was the QEP. The QEP consists mainly of three pillars (see Ugai [2007]

mixed results exist as to whether expansion of the monetary base and a change in the composition of the BOJ's balance sheet led to portfolio rebalancing. Third, the QEP created an accommodative environment in terms of corporate financing. Fourth, the QEP's effect on the real economy was limited.

for details). First, the BOJ changed the main operating target for money market operations from the uncollateralized overnight call rate to the outstanding current account balances held by financial institutions at the BOJ. Second, the BOJ increased the amount of outright purchases of long-term Japanese government bonds, up to a ceiling of the outstanding balance of banknotes issued.

Third, the BOJ introduced the policy commitment (Table 1), which is the focus of this paper. The BOJ committed itself to continuing the QEP until the year-on-year rate of change in the CPI (excluding perishables)[4] registered zero percent or higher on a sustainable basis. In October 2003, the BOJ clarified its commitment by specifying necessary conditions for the termination of the QEP. In October 2005, when the CPI inflation rate recovered, the BOJ stated in its semi-annual Outlook for Economic Activity and Price that the course of monetary policy after the exit from the QEP would be a period of very low short-term interest rates followed by a gradual adjustment to a level consistent with economic activity and price developments.

In March 2006, the year-on-year CPI inflation rate that was available to the public was 0.5 percent (Figure 2).[5] The BOJ then judged that the year-on-year change in the CPI was expected to remain positive and the conditions laid out in the commitment under the QEP had been fulfilled. Consequently, the BOJ ended the QEP. The BOJ, however, did not raise the uncollateralized overnight call rate immediately, stating that the accommodative monetary environment ensuing from very low interest rates would probably be maintained for some time. In July 2006, the BOJ raised the uncollateralized overnight call rate to 0.25 percent.

2.2 Model of the Policy Commitment

We develop the model of the policy commitment by limiting our attention to its effects on interest rates. Our model is used to examine whether the policy commitment delayed a rise in policy rates and lowered the future path of short-term interest rates.

In doing so, we clarify two assumptions associated with relationships between the QEP and the zero interest rate policy. First, we do not assume that the zero interest rate policy leads to the QEP. We allow for the possibility that the zero interest rate policy, or more broadly, low interest rate policy may be implemented without the QEP. Even after the termination of the QEP, the effects of the policy commitment possibly remain by maintaining the zero interest rate policy, delaying a rise in policy rates, and/or influencing the expected future path of short-term

[4] In Japan, it is often called the core CPI.

[5] Until August 2006, the base-year of the CPI was 2000. That CPI statistics indicated a positive inflation rate, for example, 0.5 percent in March 2006 on a real-time basis. However, when the CPI's base year changed to 2005 in August 2006, the revised CPI inflation rate fell. For example, the above inflation rate was revised from 0.5 to -0.1 percent.

interest rates.

Second, our approach rests on the assumption that the QEP leads to the zero interest rate policy. This assumption does not always hold in reality. In the wake of the global financial crisis that started in 2007, some central banks in advanced economies such as ECB and BOE conducted a series of unconventional policies by maintaining their policy rates above zero. That policy becomes possible with the help of the deposit facility that pays interest on excess reserves. Central banks can raise their policy rates without decreasing quantity target like the outstanding current account balances. Therefore, the policy commitment to continuing the QEP does not necessarily suggest that the zero interest rate policy is maintained during that period. Having said, we believe that our assumption was valid during Japan's QEP period from 2001 to 2006. The deposit facility was not adopted until 2008. Market participants appear to have believed that the zero interest rate policy would be maintained during the QEP.

2.2.1 Short-Term Interest Rate

We consider a monetary policy rule as

$$i_t^* = r^* + \pi^* + \phi(\pi_t - \pi^*), \tag{2.1}$$

where i_t^* represents a latent nominal interest rate, which can take a negative value. In the presence of the ZLB, the interest rate becomes

$$i_t = \begin{cases} 0 & \text{if } i_t^* \leq 0 \\ i_t^* & \text{if } i_t^* > 0, \end{cases} \tag{2.2}$$

without the policy commitment. Figure 3 illustrates the relationship between interest rates and inflation rates.[6] The inflation rate at which $i_t^* = 0$ is given by

$$\pi^0 = -\frac{r^* - (\phi - 1)\pi^*}{\phi}. \tag{2.3}$$

In Japan's case, if we suppose $r^* = 2\%$, $\pi^* = 1\%$, and $\phi = 1.5$, we obtain $\pi^0 = -1\%$. Thus, even if the inflation rate is negative, the policy rate may be raised from zero.

With the policy commitment, we assume a relationship between interest rates and inflation rates as in Figure 4. The interest rate is determined by

$$i_t = \begin{cases} 0 & \text{if } i_t^* \leq 0 \\ 0 & \text{if } \pi_t \leq \pi^c \\ i_t^* & \text{otherwise} \end{cases}. \tag{2.4}$$

[6] Values α and β in Figures 3 and 4 represent term premiums. They are needed for analyzing long-term interest rates.

A variable π^c indicates the threshold inflation rate. While the inflation rate is below the threshold, the central bank continues the zero interest rate policy. We assume that the latent interest rate is positive when the inflation rate equals the threshold:

$$r^* + \pi^* + \phi(\pi_t^c - \pi^*) > 0. \tag{2.5}$$

In other words, $\pi^0 < \pi^c$, meaning that the policy commitment extends the duration of the zero rate policy.[7, 8] Due to this assumption, the interest rate under the policy commitment is simplified as

$$i_t = \begin{cases} 0 & \text{if } \pi_t \leq \pi^c \\ i_t^* & \text{if } \pi_t > \pi^c \end{cases} \tag{2.6}$$

$$= I(\pi_t - \pi^c) \cdot i_t^*. \tag{2.7}$$

$I(x)$ is a function which yields one if x is non-negative and zero otherwise.

As one aspect of the policy commitment, we also consider a downward shift in the monetary policy rule when $\pi_t > \pi^c$. The BOJ emphasized in October 2005 and March 2006 that monetary policy would continue to maintain very low short-term interest rates for some time after the exit from the QEP. If that announcement is effective, it continues to influence the future path of short-term interest rates after the QEP. Regarding the monetary policy rule, such an announcement lowers its intercept $r^* + \pi^*$ and make its slope ϕ flatter, as shown in Figure 4.[9]

2.2.2 Longer-Term Interest Rates

To estimate the model, we use data for longer-term interest rates and inflation expectations. From a term structure model, a longer-term interest rate at a maturity month of T, i_t^T, is described as

$$i_t^T = \frac{1}{T} \mathrm{E}_t \left[\sum_{j=0}^{T-1} i_{t+j} \right]. \tag{2.8}$$

[7] A policy inertia, described by the dependence on the lagged interest rate, is another reason for extending the duration of the zero interest rate policy. In particular, the policy commitment under the ZLB is known to have history dependence. For example, Reifschneider and Williams (2000) propose the policy rule that responds to the accumulation of the latent nominal interests that are negative. We, however, do not incorporate this factor as a benchmark because the BOJ did not officially commit to the Reifschneider and Williams (2000) type of rule, and it is empirically difficult to calculate the size of the accumulation of the latent nominal interests if any. See Section Appendix B for an attempt to consider the policy inertia.

[8] When setting the interest rate under the policy commitment, the BOJ refers to the current state of inflation, but not to the accumulation or the spell of past negative inflation. This mitigates complexity and time-inconsistency problems intrinsic to the optimal commitment policy. In this respect, the policy commitment is closer to the one proposed by Ueda (2010) than that by Eggertsson and Woodford (2003).

[9] If the inflation rate becomes sufficiently high, the policy rate may be raised aggressively, making the slope ϕ steeper and returning to a monetary policy rule in a normal situation.

A k-month forecast of the longer-term interest rate is described as

$$\mathrm{E}_t i^T_{t+k} = \frac{1}{T}\mathrm{E}_t\left[\sum_{j=k}^{T+k-1} i_{t+j}\right] \tag{2.9}$$

$$= \frac{1}{T}\sum_{j=k}^{T+k-1} I(\mathrm{E}_t\pi_{t+j} - \pi^c)\cdot\left\{r^* + \pi^* + \phi(\mathrm{E}_t\pi_{t+j} - \pi^*)\right\}. \tag{2.10}$$

Considering a non-negative term premium α, we rewrite the above as

$$\begin{aligned}\mathrm{E}_t i^T_{t+k} = &\frac{1}{T}\sum_{j=k}^{T+k-1}\alpha\left\{1 - I(\mathrm{E}_t\pi_{t+j} - \pi^c)\right\}\\ &+ \frac{1}{T}\sum_{j=k}^{T+k-1} I(\mathrm{E}_t\pi_{t+j} - \pi^c)\cdot\left\{\alpha + r^* + \pi^* + \phi(\mathrm{E}_t\pi_{t+j} - \pi^*)\right\}.\end{aligned}$$

$$\begin{aligned}\mathrm{E}_t i^T_{t+k} = &\frac{1}{T}\sum_{j=k}^{T+k-1}\alpha\left\{1 - I(\mathrm{E}_t\pi_{t+j} - \pi^c)\right\}\\ &+ \frac{1}{T}\sum_{j=k}^{T+k-1} I(\mathrm{E}_t\pi_{t+j} - \pi^c)\cdot\left\{\beta + \phi(\mathrm{E}_t\pi_{t+j} - \pi^c)\right\},\end{aligned} \tag{2.11}$$

where

$$\beta = \alpha + r^* + \pi^* - \phi(\pi^* - \pi^c). \tag{2.12}$$

Due to assumption (2.5), we require

$$\beta > \alpha. \tag{2.13}$$

In sum, the effects of the policy commitment are evaluated by three variables: π^c, $\beta - \alpha$, and ϕ. The threshold inflation rate π^c captures a necessary condition for the termination of the QEP. A higher π^c suggests a tougher necessary condition. The intercept difference $\beta - \alpha$ and the slope ϕ determines the future path of short-term interest rates after the termination of the QEP. Both a lower $\beta - \alpha$ and a lower ϕ suggest that the BOJ raises the policy rate less aggressively in response to an increase in inflation rates.

2.2.3 Estimation Strategy

We regress equation (2.11) to examine the effects of the policy commitment. In doing so, we use the QSS. As we will explain below, from the QSS, we know only the following data on inflation expectations: $\mathrm{E}_t\pi_{t+12}$, $\mathrm{E}_t\pi_{t+24}$, and $\mathrm{E}_t\pi_{t+120}$. In addition, we use the real-time based inflation rate π_t, t being available at the time when the survey is conducted. From the four series, we linearly interpolate inflation expectations over other horizons:

$$\mathrm{E}_t\pi_{t+m} = \begin{cases} \left\{(12-m)\pi_t + m\mathrm{E}_t\pi_{t+12}\right\}/12 & \text{for } 1 \le m \le 12 \\ \left\{(24-m)\mathrm{E}_t\pi_{t+12} + (m-12)\mathrm{E}_t\pi_{t+24}\right\}/12 & \text{for } 13 \le m \le 24 \\ \left\{(120-m)\mathrm{E}_t\pi_{t+24} + (m-24)\mathrm{E}_t\pi_{t+120}\right\}/96 & \text{for } 25 \le m \le 120 \\ E_t\pi_{t+120} & \text{for } 121 \le m \end{cases}. \tag{2.14}$$

By regressing $\mathrm{E}_t i^T_{t+k}$ using explanatory variables of $\mathrm{E}_t \pi_{t+m}$, we can estimate π^c, α, β, and ϕ. We estimate α, β, and ϕ by OLS with π^c fixed, and employ a grid-search method for π^c so as to maximize the likelihood function.

3 Estimation

3.1 QSS Data

We use the QSS (QUICK Survey System) provided by QUICK corp. The QSS is a survey about market participants' sentiments. From July 1996, it asks market participants monthly about their views on equity and bond markets and the real economy. Respondents include market participants from securities firms, banks, investment trusts, insurance firms, pension funds, and other private financial institutions. The QSS is an unbalanced panel with about 150 respondents per month.

Among many survey items, we focus on surveys on expectations for interest rates and inflation rates (see Table 2). As for interest rates, we use TIBOR three months and newly issued government bonds at the maturity of two, five, ten, and twenty years. For each, one-, three-, and six-month ahead expectations for the interest rates are available. Inflation rates are expressed by the year-on-year rate of change in the CPI (excluding perishables). For each, average inflation expectations over next one, two, and ten years are available. The survey on inflation rates started in July 2004, so we are unable to analyze the effects of the adoption of QEP in 2001 on inflation expectations.

Table 3 and Figures 1 and 2 provide the basic statistics and movements of actual or expected interest rates and inflation rates. Under the QEP, inflation expectations rose steadily in accordance with actual inflation (Figure 2). That resulted in the rise in actual interest rates, as the QEP came closer to ending (Figure 1). See Appendix A for details.

3.2 Nonparametric Perspective on the Policy Commitment

3.2.1 Period under the QEP

We begin with providing a graphical presentation on the effects of the policy commitment. Figure 5 shows the relationship between interest rate expectations and inflation expectations under the QEP. The sample period is from July 2004 to February 2006; the initial period is the month when the survey on inflation rates started; and the end period is one month before the termination of the QEP. Each dot indicates a respondent's expectation at a certain month. We plot interest rate expectations over three-month horizons, because those over one-

and six-month horizons are similar. Five panels show interest rate expectations for three-month TIBOR, two-, five-, ten-, and twenty-year government bonds. The horizon of inflation expectations is one year.[10] A solid line indicates the mean of interest rate expectations obtained from a nonparametric kernel smoothing regression, with its asymptotic variability bounds being indicated by dashed lines.[11]

We find a kinked relationship between interest rate expectations and inflation expectations. In particular, for three-month TIBOR and two- and five-year government bonds, the presence of the kink is clear at the threshold of inflation expectations around zero percent. The kinked relationship resembles that in Figure 4. For long-term interest rates, the kink is unclear.

When inflation expectations remain below the threshold, the slope of interest rate expectations is flat. That suggests that market participants anticipated the continuation of the QEP and the unchanged low interest rate. Such a response is consistent with the BOJ's policy commitment to continuing the QEP until the CPI inflation rate became stably zero or higher.

When inflation expectations exceed the threshold, the slope becomes gently positive. Although increases in interest rate expectations are accompanied by increases in inflation expectations, such increases in interest rate expectations are gradual, in particular, for three-month TIBOR. Such a response is consistent with the BOJ's announcement that monetary policy would continue to maintain very low short-term interest rates for some time after the exit from the QEP.

3.2.2 Dependence on Sample Periods

For comparison, we next investigate changes in expectations during and after the QEP. First, we divide the sample period of the QEP into two. In Figure 6, the middle period of the QEP is from July 2004 to June 2005, denoted by a circle (o), and the latter period is from July 2005 to June 2006, denoted by a plus (+). As for the latter period, we extend the sample period until June 2006 instead of February 2006 to ensure enough samples. From March to July in 2006, the BOJ ended the QEP but maintained to target almost the zero interest rate.

Comparing the two periods, we find two things. First, the dots in the figure move to the right, suggesting an increase in inflation expectations. This is accompanied by the increase in the actual CPI inflation rate. Second, interest rate expectations for three-month TIBOR and two-year government bonds are higher and steeper in the latter period than those in the middle period. That implies that as the actual CPI inflation rate increased to the threhold, market

[10] Figures A-7 and A-8 show inflation rate expectations over two- and ten-year forecast horizons.

[11] We use R to employ the nonparametric kernel smoothing regression. The Nadaraya-Watson method is applied. The band width is chosen by least-squares cross-validation, and the kernel type is continuous second-order Gaussian.

participants became more mindful of the end of the QEP. For ten-year government bonds, there was almost no change.

We next plot interest rate expectations vis-a-vis inflation expectations after the QEP ended. Figure 7 shows interest rate expectations vis-a-vis inflation expectations. Considering that the BOJ raised the call rate from almost zero to 0.25 percent in July 2006, we use the sample after August 2006. The sample ends in November 2008, so it includes the time of the global financial turmoil. Note that the BOJ did not introduce the policy commitment during that time. To highlight the differences between two policy regimes, Figure 8 plots their means obtained from a kernel smoothing regression with those during the QEP. Upper and lower lines represent the means during and after the QEP, respectively, with their asymptotic variability bounds being indicated by dashed lines.

Figures 7 and 8 illustrate mainly two things. First, at short- to medium-term maturities, we find that interest rate expectations after the QEP ended are higher than those during the QEP, after controlling the level of inflation expectations. Their difference indicates the size of the policy commitment effect on interest rates.[12] For three-month TIBOR, it amounts to about 0.7 percent point. For two-year government bonds, it amounts to about 0.5 percent point. In both cases, differences appear to be significant. As the maturity lengthens, their difference becomes smaller and insignificant.

Second, after the QEP ended, interest rate expectations are more broadly scattered. Their dependence on the inflation rate is weaker, and no clear kink is observed at all maturities. Those differences highlight the effects of the policy commitment that conditioned its policy on the developments in the CPI inflation rate.

3.3 Estimation Results

So far we have examined the effects of the policy commitment graphically. In this subsection, we analyze the effects quantitatively by estimating the model.

3.3.1 Benchmark

We regress equation (2.11) to examine the effects of the policy commitment. As for explanatory variables, we use not only inflation expectations over three different forecast horizons (one, two,

[12] In order to gauge the policy effect by the difference in the interest rate, two conditions need to be satisfied. First, the effects of the policy commitment are completely dispelled in the post period. Second, macroeconomic situations other than inflation are the same between the two periods. Importantly, tradeoff exists between those two conditions. Here we attempt to meet the first condition by using a sufficiently long sample after the QEP, but it sacrifices the second condition. See Appendix B for another approach using short samples during and after the QEP.

and ten years) but also the actual inflation rate. This is because, as equation (2.14) shows, we need to match the time horizon of interest rates with that of the inflation rates. Regarding the actual inflation rate, we use the real-time year-on-year CPI (excluding perishables) inflation rate that was available to market participants at the time of survey. We search for π^c using a grid of 0.01 percent point so that it maximizes the likelihood function. The sample period is from July 2004 to February 2006. There are about 3,000 samples. Table 4 reports the estimated coefficients of π^c, α, β, and ϕ, with adjusted R^2.

We employ simple pooled regression. We do not control fixed nor random effects associated with panel data. We do not use the Tobit model, either. We choose to do so for the following reasons. First, observed interest rates are not strictly zero due to a term premium. The term premium may differ across market participants. The standard Tobit model is thus not applied. Second, when regressing qualitative dependent variable using a panel data, an incidental parameter problem arises. That problem has been long pointed out by, for example, Neyman and Schott (1948), Honore (1992), and Lancaster (2000). It states that a fixed effect is hard to separate from the threshold that determines a kink in the dependent variable. For those reasons, we employ simple pooled regression as a benchmark and check the robustness of our results by using a modified Tobit model and a subset of samples.[13]

Estimation results in Table 4 are in line with the theory of the policy commitment discussed in Section 2.2. We begin with examining three-month TIBOR. Regarding the threshold inflation rate for the policy commitment π^c, we obtain its estimate around zero percent. That coincides with the necessary condition for the termination of the QEP: under the QEP, the BOJ committed to maintaining the QEP until the CPI inflation rate became stably zero or higher. Regarding the rise in the call rate at the threshold, the estimated difference between α and β is small and insignificant. Regarding the pace of interest rate rises, the estimated slope of the Taylor rule ϕ is significantly positive and smaller than one. The last two results suggest that the policy commitment not just delayed the timing of the termination of the QEP but also reduced expectations for the future path of short-term interest rates after the termination of the QEP. Those results coincide with the BOJ's policy commitment to maintaining an accommodative monetary environment for some time even after the QEP.[14] Regarding the goodness

[13] See Appendix B for details.

[14] Several other reasons are considered as to why ϕ is less than one. First, the zero lower bound may have caused a downward bias in our estimates. Second, other economic varibles, which are not available in the survey, may have caused a bias in estimates. Third, the effects of uncertainty may not be adequately incorporated as in the macro-finance model. Fourth, policy inertia may have led to a slow response to a change in inflation, thereby yielding a low ϕ. This last possibility is strongly related to the BOJ's commitment and is examined in Appendix B.

of fit, adjusted R^2 is about 0.2 to 0.3.

We next examine medium-term interest rates at two- and five-year maturities. The threshold inflation rate π^c is around 0.1 percent. The slope ϕ is about 0.2, which is significantly positive and smaller than one. Such results are similar to those for three-month TIBOR. One notable difference is that the intercept β is significantly larger than α by about 0.2 percent point. That implies that, as the forecast horizon lengthens, market participants took rises in the policy rate as a more likely event even though the level of inflation expectations stayed unchanged. Adjusted R^2 is the highest for two-year government bonds, reaching 0.4.

As for long-term interest rates, we find similar but weaker results. Adjusted R^2 does not exceed 0.1. One reason is that over a long time horizon, market participants attach greater importance to other variables than to the CPI inflation rate. For example, forecasts about fiscal deficits and the steady-state real interest rate play a more important role. Consequently, market participants do not devote serious effort to forecast about long-term inflation rates. On the BOJ's side, weak relationships between interest rate expectations and inflation expectations may be explained by the fact that the time horizon of the BOJ's forecast is at most over next two years and that the terms of office is five years for the members of the policy board.

3.3.2 Dependence on Sample Periods

Table 5 reports estimation results for varying sample periods. The middle period is from July 2004 to June 2005, the latter period is from July 2005 to June 2006, and the post period is from August 2006 to November 2008. We focus on three-month forecasts of interest rates, because results are similar for one and six-month forecasts of interest rates.

Comparing with the middle and the latter periods, we find that the goodness of fit is far better in the latter period than in the middle period. For three-month TIBOR, adjusted R^2 is 0.54 in the latter period while it falls to 0.01 in the middle period. In the latter period, most parameter estimates are consistent with the theory, yielding $\beta > \alpha > 0$ and $0 < \phi < 1$. For three-month TIBOR, a difference between α and β is as small as 0.06 percent point, and ϕ is 0.5. The threshold inflation rate π^c is about 0.1 percent for three-month TIBOR and 0.3 percent for two- and five-year government bonds. Some parameter estimates in the middle period are inconsistent with theory prediction. The estimated ϕ is negative for two-year government bonds.

Those differences between the middle and latter periods are explained by the difference of actual inflation rates, and in turn, the difference of market participants' attitudes in forming their expectations. In the middle period, the actual CPI inflation rate remained sufficiently below a threshold. The necessary condition for the end of the QEP was not satisfied at that

time, and market participants did not anticipate the end of the QEP in the near future. Therefore, market participants did not need to pay much attention to inflation outlook in order to forecast interest rates. That made the relationship between inflation and interest rates ambiguous. However, in the latter period, the actual CPI inflation increased to the threshold. The market participants began to prepare for the end of the QEP. They started to monitor actual inflation and forecast inflation carefully to forecast interest rates. That led to a clearer relationship between inflation and interest rates, and in turn, the better fit of the model in the latter period than in the middle period. Those results suggest that the policy commitment effect on market expectations becomes stronger as the economy recovers, which is consistent with views expressed by Shirakawa (2010).[15]

Regarding the post period, we find that the goodness of fit in the post period is worse than that during the QEP. Adjusted R^2 declines, β is lower than α for short to medium-term bonds, and ϕ is negative for medium-term bonds. That reflects the obvious fact that the policy commitment was not implemented in the post period. In addition, the lower performance in the post period suggests that monetary policy was less responsive to CPI inflation, because the BOJ no longer employed the policy commitment that referred to the CPI.

Comparisons of $\alpha(\beta)$ between the benchmark and the post period give us a clue about the size of the policy commitment effect. For three-month TIBOR, its difference amounts to 0.8 (0.6) percent point. For two-year government bonds, its difference amounts to 0.8 (0.5) percent point. Other things being equal, we can interpret that those differences indicate the size of the interest rate reduction by the policy commitment.[16]

4 Concluding Remarks

Using the survey on interest rate and inflation expectations, we have evaluated the effects of the BOJ's policy commitment on market expectations. This survey is valuable, because otherwise it is difficult to identify whether low interest rate expectations are due to the policy commitment or simply due to low inflation expectations. Our analysis has revealed a kinked relationship between interest rate expectations and inflation rate expectations at the threshold level of inflation expectations at zero percent, in tune with the necessary condition for the termination of the QEP. In addition, even when inflation expectations exceeded the threshold, interest rate

[15] Shirakawa (2010) argues "the policy duration effect could exert significant easing effects, especially when economic recovery progresses and corporate profits improve."

[16] Of course, macroeconomic situations are very different between the two samples. For example, oil and commodity prices jumped, and the subprime mortgage problem occurred in the post period. We conduct a robustness check in Appendix B.

expectations responded only gradually to inflation rate expectations. Those results indicate the importance of evaluating the effects of the policy commitment on market expectations not just for the timing of the termination of the QEP but also for the future path of short-term interest rates after the termination of the QEP.

The future work needs to be extended mainly in three directions. The first concerns implications for the real economy in a general equilibrium context. In this paper, we have treated inflation expectations as an explanatory variable and analyzed the effects of the policy commitment on market participants' interest rate expectations. This approach is not exempt from the endogeneity problem in that the policy commitment is considered to influence inflation expectations by lowering interest rate expectations. Moreover, we have not considered the effects of the policy commitment on real economic activity and actual inflation rates.[17] We need a general equilibrium framework to analyze those effects with a theoretical model of the policy commitment.

Second, we need to pay more attention to the central bank's balance sheet. On a liability side, the current account balances held by financial institutions at the BOJ served as the official target under the QEP. The target level increased step by step from five trillion yen in March 2001 to the band of 30 to 35 trillion yen in March 2006 (see Figure 9). On an asset side, the BOJ's balance sheet changed its composition. The BOJ increased the amount of the outright purchase of long-term Japanese government bonds. From July 2003 to March 2006, the BOJ purchased asset-backed securities. Those balance-sheet policies may have influenced financial markets and the real economy. For example, there is a possibility that the accumulation of the current account balances up to 35 trillion yen made market participants believe that excess reserves would be adjusted only gradually, reducing market expectations for the future path of short-term interest rates at the final stage of the QEP. To investigate the effects of balance-sheet policies thoroughly, the survey data on inflation expectations provided limited information. Its survey started after the target level reached the band of 30 to 35 trillion yen, and while the survey was conducted, the target level of current account balances stayed unchanged until the QEP ended. Nevertheless, research in that direction is clearly needed.

Third, similar assessments need to be applied to other advanced countries. In the wake of the recent financial crisis, central banks introduced various unconventional policies. In particular, as for policy commitment, Bank of Canada adopted an explicit conditional commitment. The Federal Reserve announced that they would maintain exceptionally low levels for the federal funds rate for some time. The Bank of England did not introduce explicit policy commitment.

[17] For example, the recent work by Nakajima, Shiratsuka, and Teranishi (2010) employs a time-varying VAR model to analyze the effects of the policy commitment on output and prices.

The European Central Bank did not conduct explicit policy commitment, but introduced the fixed-rate, full-allotment operation at the maturity of one year. It is interesting to see whether we can observe a similar kinked relationship between interest rate expectations and inflation rate expectations.

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Table 1: BOJ's policy commitment

Date	Policy
Mar. 19, 2001	Committing that the QEP continues to be in place until the CPI (excluding perishables) inflation registers stably a zero percent or an increase year on year.
Oct. 10, 2003	Enhancing monetary policy transparency. BOJ's commitment is underpinned by the following two conditions. 1. it requires not only that the most recently published core CPI should register a zero percent or above, but also that such tendency should be confirmed over a few months. 2. the BOJ needs to be convinced that the prospective CPI inflation will not be expected to register below a zero percent. The above conditions are the necessary condition. There may be cases, however, that the BOJ will judge it appropriate to continue with the QEP even if these two conditions are fulfilled.
Oct 31, 2005	Release of Outlook for Economic Activity and Prices. The possibility of a departure from the present monetary policy framework is likely to increase over the course of fiscal 2006. The course of monetary policy after the change of the framework will be a period of very low short-term interest rates followed by a gradual adjustment to a level consistent with economic activity and price developments.
Mar. 9, 2006	Exit from the QEP by changing the operating target to the uncollateralized overnight call rate. Encouraging the uncollateralized overnight call rate to remain at effectively zero percent. As for the future interest rate, the BOJ states that an accommodative monetary environment ensuing from very low interest rates will probably be maintained for some time.
Jul. 14, 2006	Encouraging the uncollateralized overnight call rate to remain at around 0.25 percent.

Table 2: Questionnaires in the QSS

Item	Time horizon of forecast	Period
TIBOR rate (3 months)	1, 3, 6 months	2000M5 – 2008M11
Newly issued JGB rate (2 years)	1, 3, 6 months	2001M5 – 2008M11
Newly issued JGB rate (5 years)	1, 3, 6 months	2001M5 – 2008M11
Newly issued JGB rate (10 years)	1, 3, 6 months	1998M7 – 2008M11
Newly issued JGB rate (20 years)	1, 3, 6 months	2003M4 – 2008M11
CPI (excluding perishable) inflation	Average of 1, 2, 10 years	2004M7 – 2008M11

Note: JGB represents Japanese government bonds.

Table 3: Basic statistics

Item	1M forecast	3M forecast	6M forecast
TIBOR (3M)	0.303%	0.322%	0.351%
	(0.296)	(0.306)	(0.326)
JGB (2Y)	0.359%	0.387%	0.426%
	(0.334)	(0.356)	(0.386)
JGB (5Y)	0.774%	0.816%	0.871%
	(0.366)	(0.380)	(0.400)
JGB (10Y)	1.503%	1.563%	1.639%
	(0.308)	(0.315)	(0.327)
JGB (20Y)	2.047%	2.099%	2.161%
	(0.282)	(0.280)	(0.282)

Item	1Y average	2Y average	10Y average
CPI (excluding perishable)	0.367%	0.553%	1.131%
inflation	(0.415)	(0.305)	(0.154)

Note: Upper and lower numbers in parenthesis indicate the means and the standard deviation, respectively.

Table 4: Estimation results (benchmark)

dependent variables		#N	α	S.E.	β	S.E.	ϕ	S.E.	π^c	Adj R^2
	1M	2,566	0.089	0.000	0.092	0.002	0.189	0.018	0.02	0.193
TIBOR	3M	2,566	0.093	0.001	0.095	0.002	0.249	0.013	-0.04	0.256
	6M	2,565	0.100	0.001	0.134	0.003	0.192	0.018	0.01	0.270
	1M	2,915	0.111	0.002	0.255	0.005	0.159	0.020	0.10	0.422
2Y	3M	2,874	0.118	0.003	0.287	0.005	0.153	0.020	0.10	0.413
	6M	2,852	0.137	0.004	0.299	0.006	0.170	0.019	0.10	0.350
	1M	2,952	0.527	0.009	0.683	0.008	0.209	0.018	0.06	0.197
5Y	3M	2,953	0.551	0.009	0.757	0.008	0.206	0.018	0.09	0.232
	6M	2,933	0.622	0.009	0.849	0.009	0.181	0.020	0.15	0.233
	1M	2,964	1.322	0.026	1.434	0.007	0.066	0.009	-0.11	0.035
10Y	3M	2,966	1.447	0.008	1.562	0.008	0.054	0.013	0.29	0.065
	6M	2,947	1.499	0.009	1.666	0.009	0.049	0.015	0.34	0.094
	1M	2,926	1.930	0.045	2.055	0.006	0.026	0.006	-0.20	0.012
20Y	3M	2,925	1.896	0.051	2.104	0.007	0.051	0.006	-0.20	0.035
	6M	2,905	2.168	0.006	2.254	0.008	0.047	0.011	0.50	0.060

Note: #N indicates the number of sample. The sample period is July 2004 to February 2006.

Table 5: Changes in parameters for differing samples

	α				β			
	Benchmark	Middle	Latter	Post	Benchmark	Middle	Latter	Post
TIBOR	0.093	0.088	0.108	0.852	0.095	0.092	0.114	0.680
2Y	0.118	0.136	0.194	0.958	0.287	0.197	0.563	0.763
5Y	0.551	0.547	0.666	1.290	0.757	0.623	1.069	1.243
10Y	1.447	1.265	1.428	1.713	1.562	1.465	1.728	1.703
20Y	1.896	1.869	2.099	2.113	2.104	2.086	2.197	2.202
	ϕ				π^c			
	Benchmark	Middle	Latter	Post	Benchmark	Middle	Latter	Post
TIBOR	0.249	0.008	0.478	0.083	-0.040	-0.230	0.090	0.100
2Y	0.153	-0.055	0.440	-0.014	0.100	0.210	0.280	0.400
5Y	0.206	0.101	0.382	-0.105	0.090	-0.200	0.300	0.400
10Y	0.054	0.082	0.124	-0.059	0.290	-0.200	0.400	0.480
20Y	0.051	0.073	0.050	0.012	-0.200	-0.200	0.490	0.220
	Adj R^2							
	Benchmark	Middle	Latter	Post				
TIBOR	0.256	0.013	0.538	0.213				
2Y	0.413	0.043	0.616	0.185				
5Y	0.232	0.042	0.439	0.052				
10Y	0.065	0.039	0.266	0.019				
20Y	0.035	0.049	0.075	0.009				

Note: Dependent variables are forecasts over three-month forecast horizon.

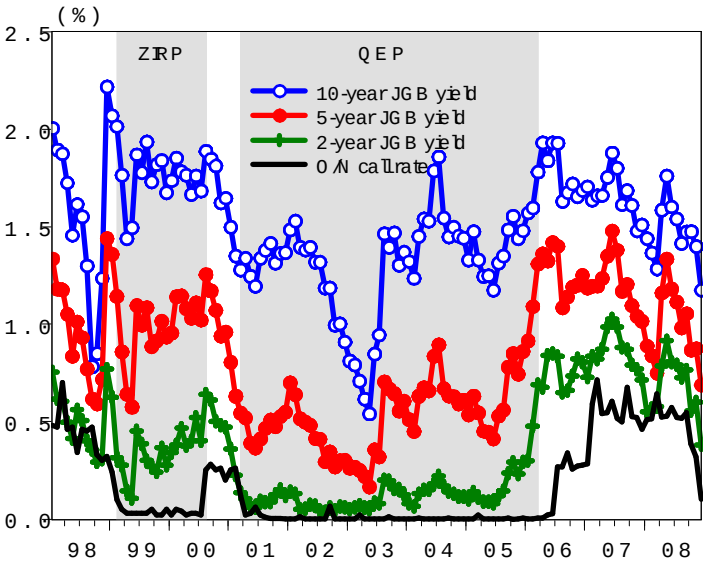

Figure 1: Interest rates. Sources: Bloomberg; Bank of Japan

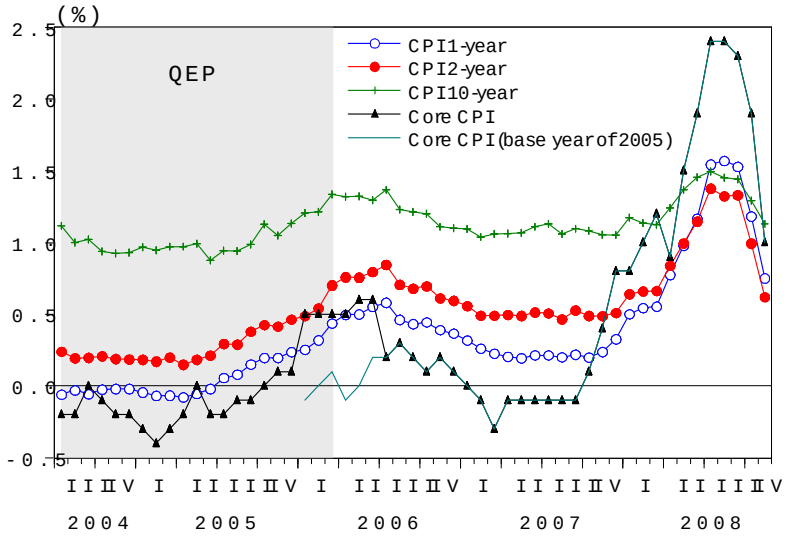

Figure 2: Actual and expected inflation. Sources: QUICK corporation "QUICK Survey System"; Statistics Bureau

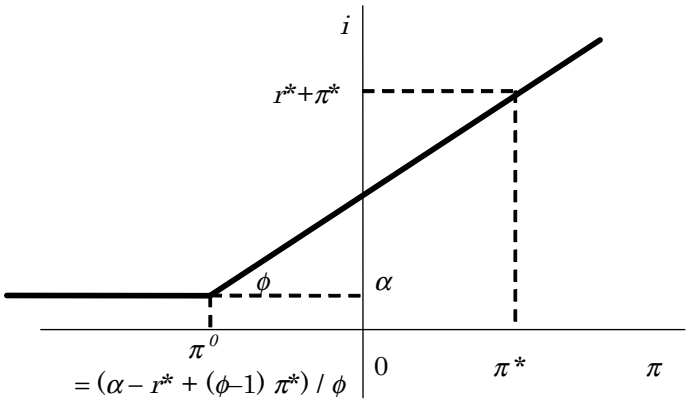

Figure 3: Monetary policy with the ZLB and without the policy commitment

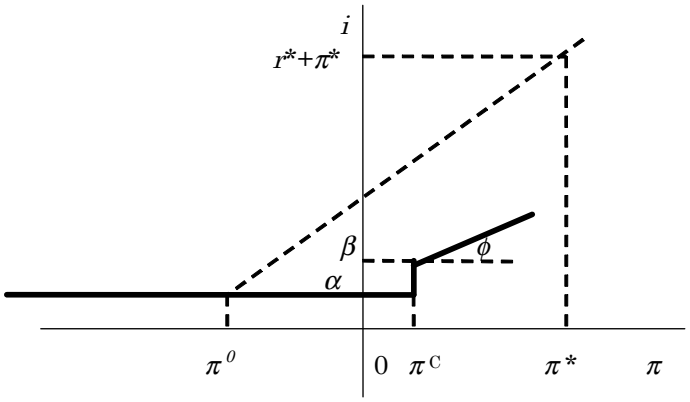

Figure 4: Monetary policy with the ZLB and the policy commitment

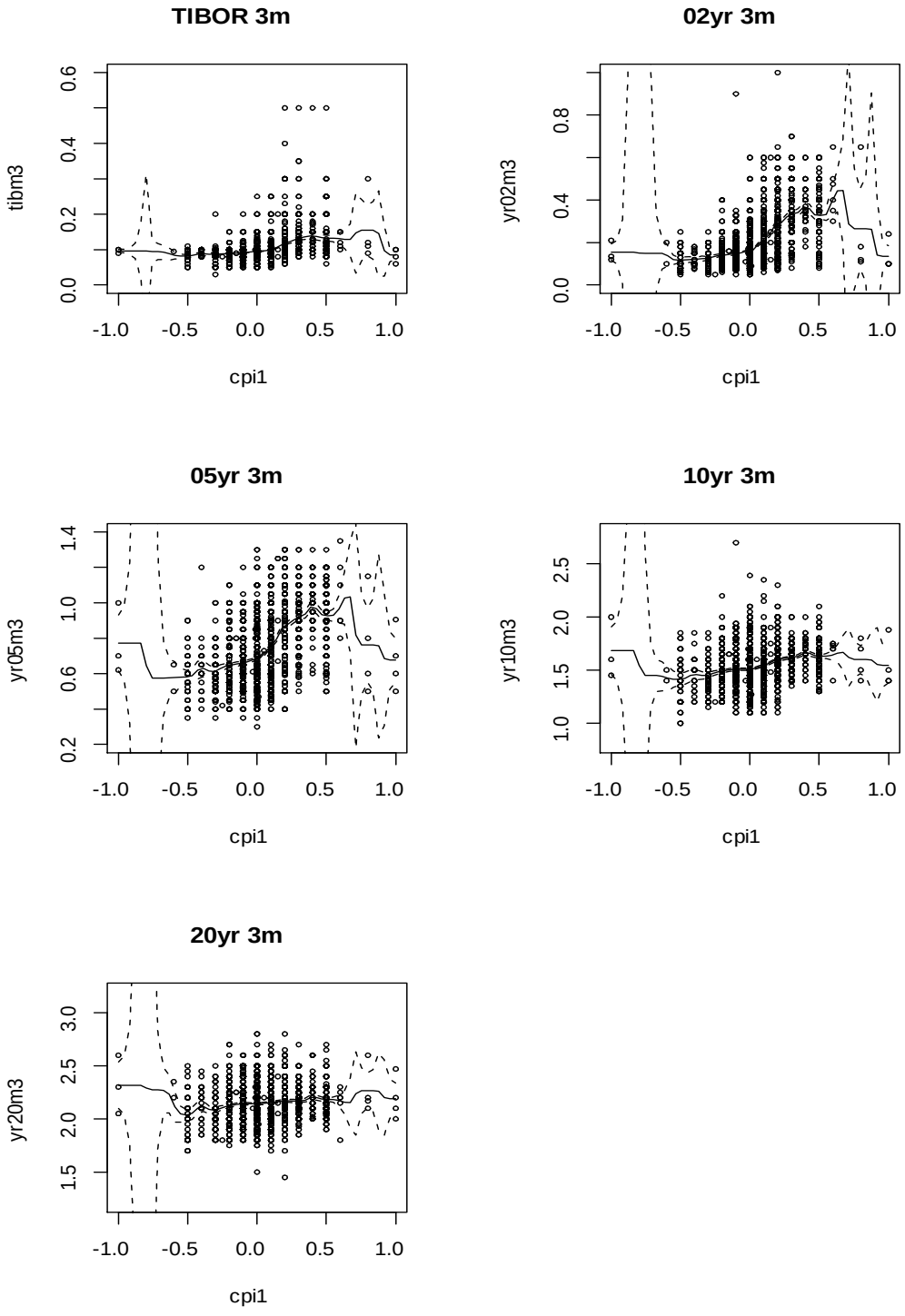

Figure 5: Interest rate expectations vis-a-vis one-year inflation expectations

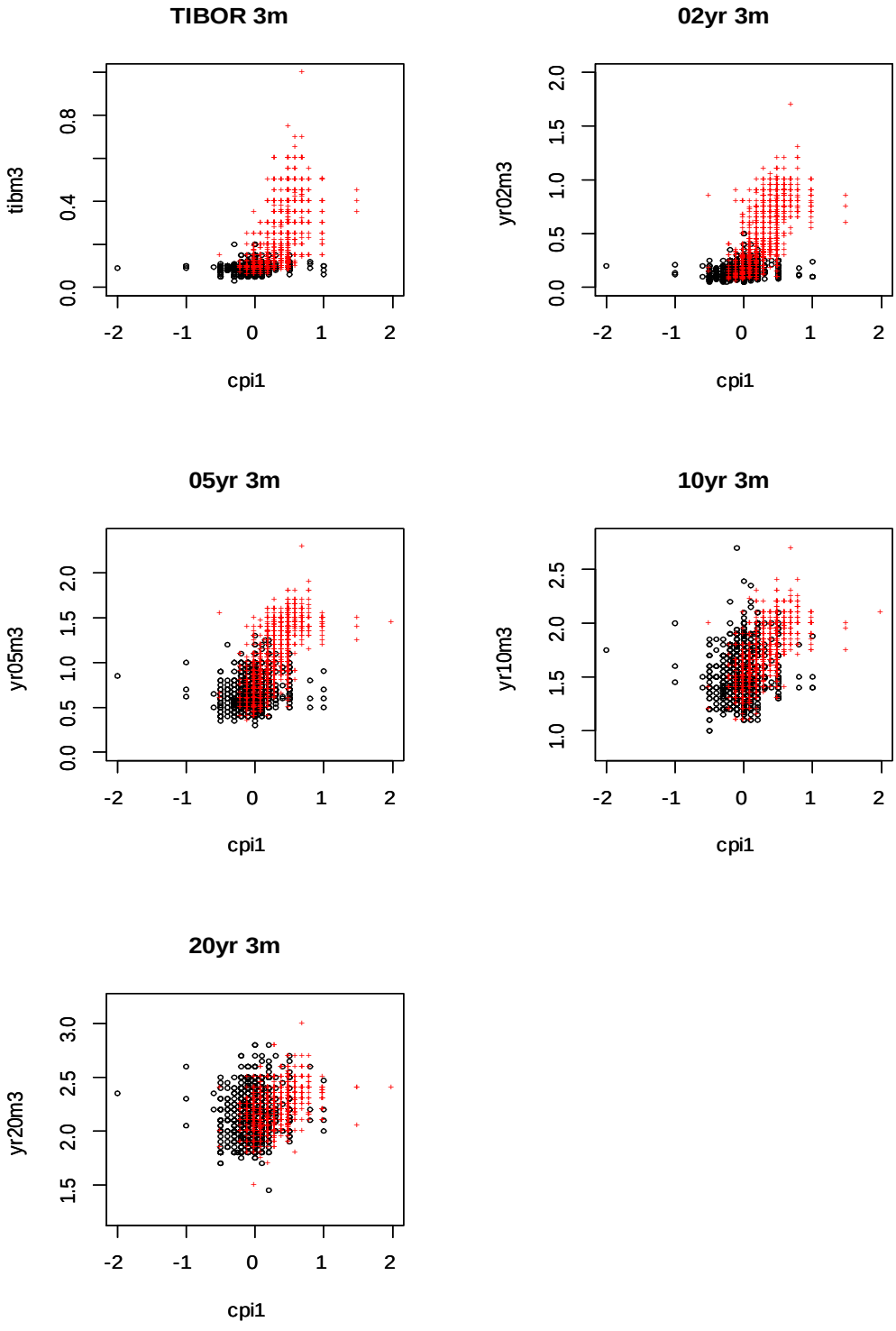

Figure 6: Interest rate expectations vis-a-vis one-year inflation expectations in the middle and latter period of the QEP

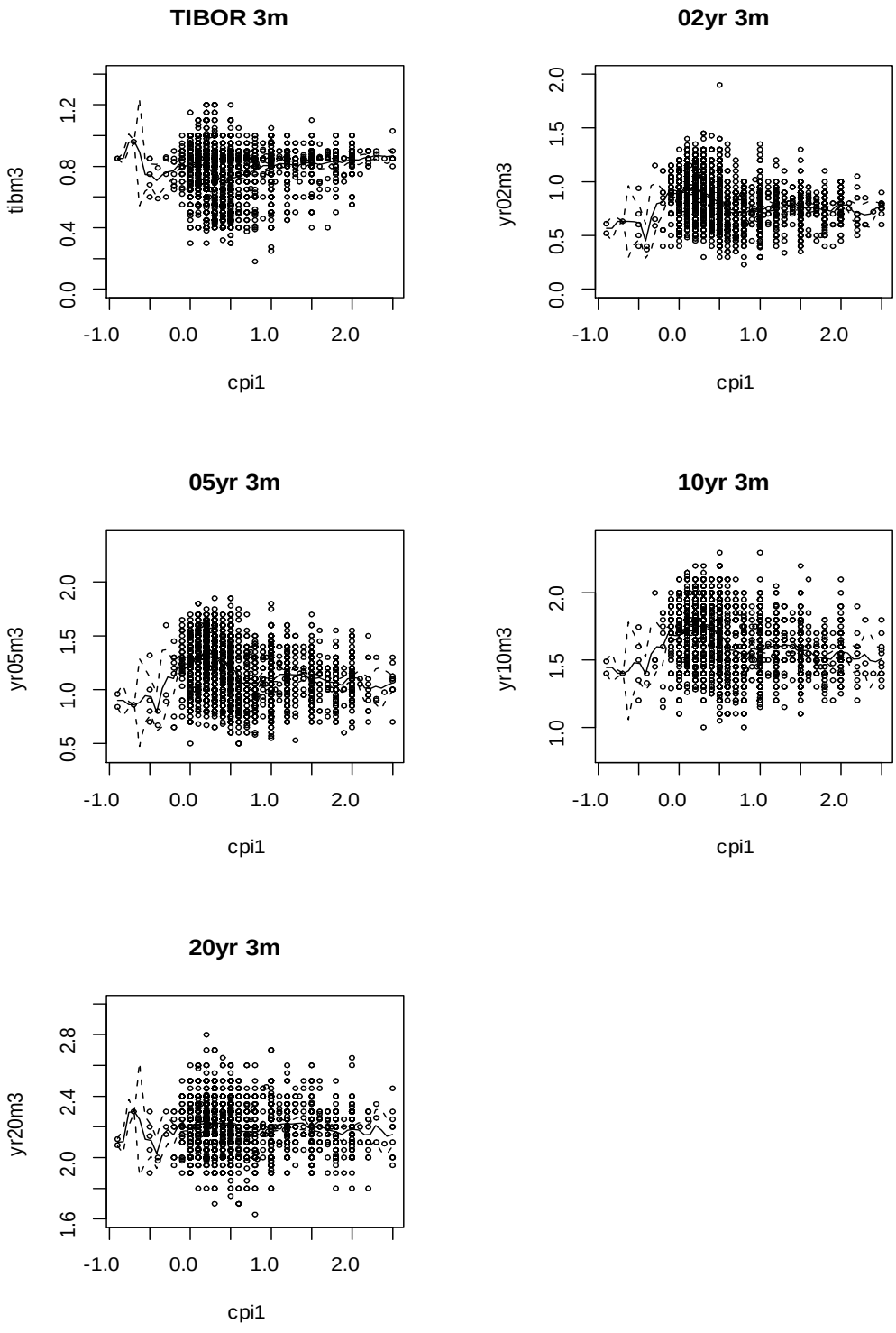

Figure 7: Interest rate expectations vis-a-vis one-year inflation expectations after the QEP ended

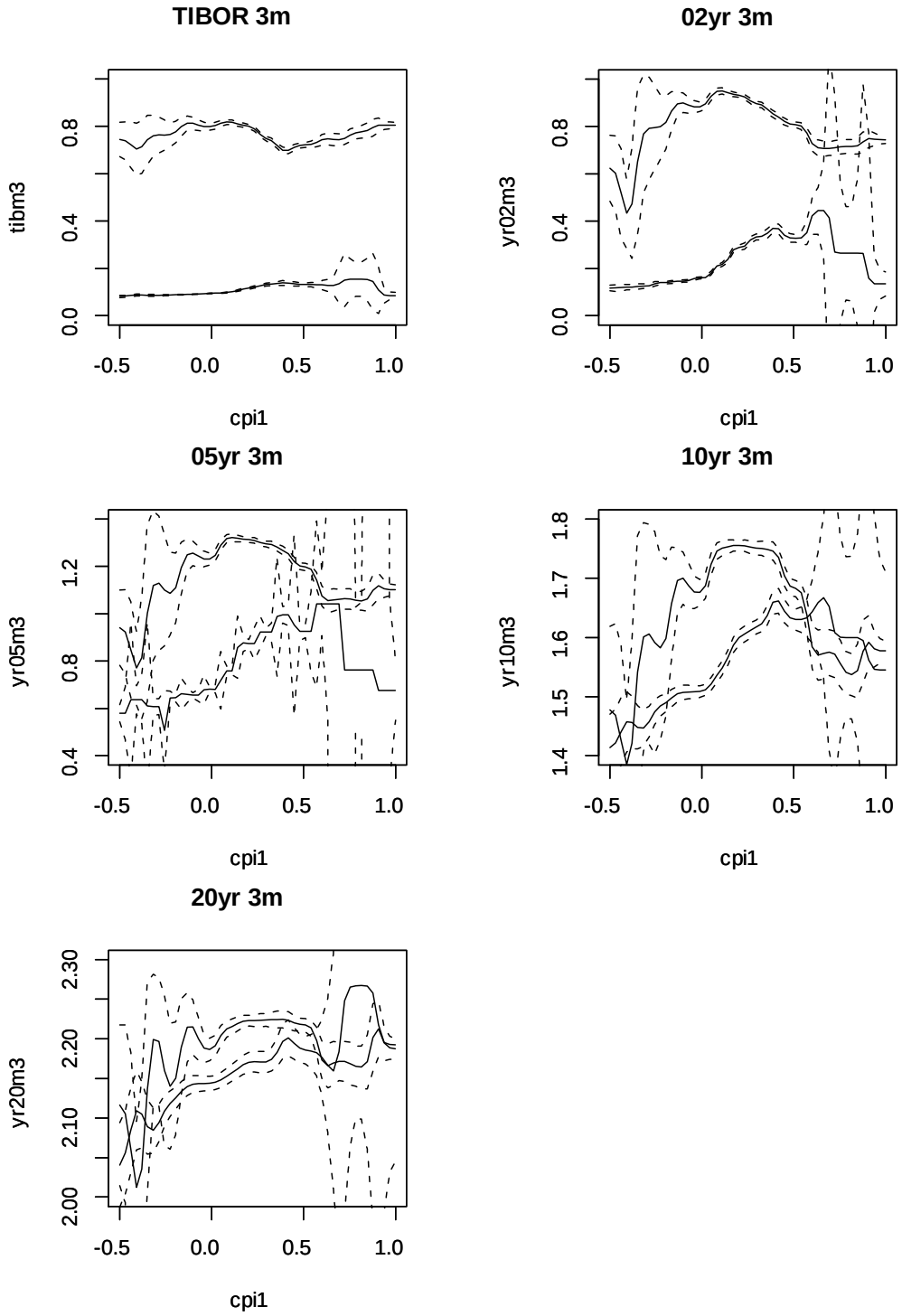

Figure 8: Interest rate expectations vis-a-vis one-year inflation expectations during and after the QEP

Note: Upper and lower lines represent the means during and after the QEP, respectively.

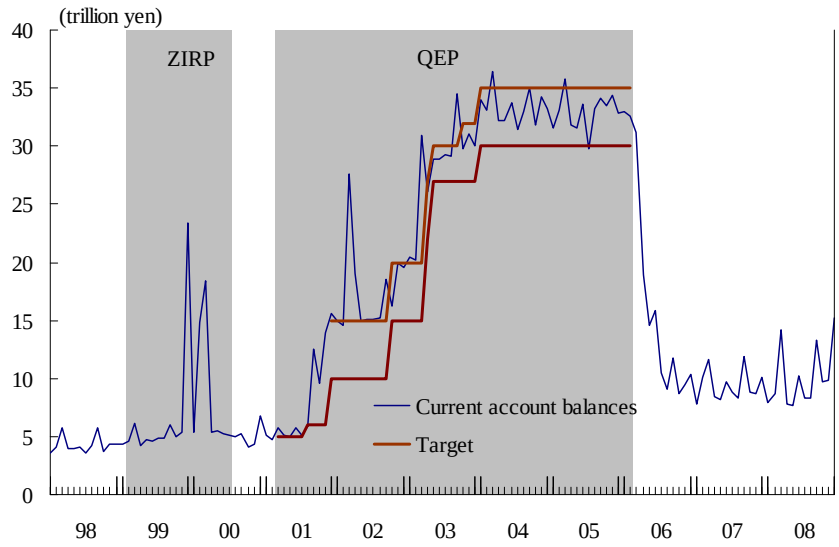

Figure 9: Current account balances

Source: Bank of Japan

Appendix

A QSS Data

In this Appendix, we report the data in the QSS in more details. We plot the mean, the ratio of the standard deviation to the mean, and the skewness with the CPI inflation rate. A shaded area indicates the period of the QEP.

A.1 Interest Rate Expectations

Figures A-1 to A-5 plot interest rate expectations. As for the mean of interest rate expectations, short- to medium-term bond interest rates were low and stable under the QEP. Some months before the exit from the policy, those interest rates picked up gradually. Long-term bond interest rates were relatively high and unstable.

We next examine the variation of interest rate expectations in view of the ratio of the standard deviation to the mean. We do not look at a simple standard deviation, because the standard deviation obviously decreases due to the decrease in the level of the interest rate under the QEP. According to this measure, the variation of the short to medium-term bond interest rates decreased slowly under the QEP. That implies that the policy commitment lowered the level of short to medium-term bond interest rates on impact, but stabilized them over time. It is considered to reflect the gradual propagation of the policy commitment among market participants. Or it is considered to reflect regained stability of financial markets and the financial system. A few months before the exit from the QEP, the variation of three-month TIBOR interest rates started to increase.

The skewness of interest rate expectations for short- to medium-term bond interest rates was positive in most of the periods under the QEP. That suggests that some market participants expected very high interest rates, but the ZLB prevented them from expecting negative interest rates. The skewness of interest rate expectations for long-term bond interest rates was nearly zero. That suggests symmetric expectations at those maturities.

A.2 Inflation Expectations

Figure A-6 plots inflation expectations. As for the mean of inflation expectations, we find four things. First, inflation expectations over next one- and two-year horizons increased steadily from 2004 to 2006. That movement was correlated with that in the actual CPI. Second, over the one-year horizon, market participants expected the positive inflation rate in mid-2005, one year earlier than the exit in March 2006. Over the two-year horizon, inflation expectations

were positive when the survey started in mid-2004. Third, ten-year inflation expectations were stable over the entire sample periods. Its mean was 1.1 percent, which is in the range of the understanding of medium to long-term price stability clarified by the policy board at the BOJ: between zero to two percent with median figure around one percent. Fourth, from the end of 2007, inflation expectations rose, reflecting the wake of the financial crisis and the surge in commodity prices.

The middle panel plots the standard deviation of inflation expectations. Since the mean of inflation expectations fluctuates around zero, unlike previous figures, we do not plot the ratio of the standard deviation to the mean. The standard deviation was stable during the QEP. It then increased from 2007.

The skewness of inflation expectations was positive in most of the periods. That suggests that some market participants expected very high inflation rates.

A.3 Relationship between Interest Rate Expectations and Inflation Expectations

Figures A-7 and A-8 show a relationship between interest rate expectations and inflation expectations. As for inflation expectations, we used one-year inflation rate expectations to plot Figure 5. Here, we use two- and ten-year inflation expectations.

Those figures suggest an ambiguous relationship between interest rate expectations and inflation expectations for longer-term inflation expectations.

B Robustness Checks

In this appendix, we check the robustness of our results.

B.1 Model without the Policy Commitment

First, we examine how the monetary policy rule is estimated if we do not introduce the model without the policy commitment. By this, we mean the policy without the threshold inflation rate π^c. Under the policy, the timing of the termination of the QEP is not delayed. Note, however, that the policy still plays a role in reducing the future path of short-term interest rates after the termination of the QEP by having $\beta \sim \alpha$ and small ϕ.

The expected interest rate in the model without the policy commitment corresponds to

equation (2.11) with the constraints $\beta = \alpha$ and $\pi^0 = \pi^c$:

$$\begin{aligned} \mathrm{E}_t i_{t+k}^T = & \frac{1}{T} \sum_{j=k}^{T+k-1} \alpha \left\{ 1 - I(\mathrm{E}_t \pi_{t+j} - \pi^0) \right\} \\ & + \frac{1}{T} \sum_{j=k}^{T+k-1} I(\mathrm{E}_t \pi_{t+j} - \pi^0) \cdot \left\{ \alpha + \phi(\mathrm{E}_t \pi_{t+j} - \pi^0) \right\}, \end{aligned} \tag{B.1}$$

where

$$\pi^0 = -\frac{r^* - (\phi - 1)\pi^*}{\phi} < \pi^c. \tag{B.2}$$

Equation (2.12) suggests that equation (B.1) is equivalent to equation (2.11) with

$$\beta - \alpha = \phi(\pi^c - \pi^0). \tag{B.3}$$

Table B-1 reports results when we estimate equation (B.1). It suggests the validity of the policy commitment model. The performance of the model without the policy commitment is poorer than that of the model with the policy commitment. Adjusted R^2 is significantly lower at all the maturities except for three-month TIBOR. For example, for two-year government bonds, adjusted R^2 is 0.35 while it is 0.41 in the model with the policy commitment. The table also suggests that, without consideration of the policy commitment, we tend to find weaker commitment effects. Estimates reveal that π^0 is lower than or at most equal to π^c. For two-year government bonds, the difference of inflation rates, $\pi^c - \pi^0$, is 0.15 percent point. By that size, the policy commitment makes the continuation of the QEP more probable.

Significant model differences are not observed for three-month TIBOR. However, as is stated above, that does not imply that the policy commitment was ineffective. Rather, that reflects the fact that the effects of the policy commitment continued to remain even after the end of the QEP. The call rate did not jump at the threshold inflation rate, making estimated α and β almost the same.

B.2 Sample Period

In the main text of this paper, we compare estimates between the benchmark period and the post period to evaluate the effects of the policy commitment. However, those estimates may not be comparable, because macroeconomic circumstances may greatly differ. The post period includes the recent episode of the financial crisis, when GDP dropped, unemployment rose, and financial markets and the financial system were destabilized. The post period also includes the time when oil and food prices soared. Over the long sample, the equilibrium real interest and inflation rates are subject to changes.

In this appendix, we compare shorter sample periods just before and just after the QEP ended. By comparing graphs and estimates, we attempt to control changes in macroeconomic circumstances.

Before showing results, let us emphasize one drawback of this approach. Even though the QEP ended in March 2006, it does not mean that the policy commitment ended. Before and when the QEP ended, the BOJ stated that it would maintain the low interest rate environment for some time. That statement is considered to have reduced interest rate expectations after the QEP ended. Therefore, comparing estimates from shorter sample periods just before and just after the QEP ended has the risk of underestimating the size of the policy commitment.

Figure B-1 demonstrates the interest rate expectations vis-a-vis inflation expectations for differing three sample periods: from December 2005 to February 2006, just before the QEP ended, denoted by a blue circle (o); from April 2006 to June 2006, when the QEP ended but the zero interest rate policy was maintained, denoted by a red dot ($\cdot$); and from August 2006 to October 2006, just after the Bank of Japan raised its policy rate to 0.25 percent, denoted by a green plus (+). The figure generally shows a positive slope: an increase in interest rate expectations is accompanied with an increase in inflation expectations. The increase in interest rate expectations is distinct for three-month TIBOR, reflecting the actual rise in the call rate.

We then estimate parameters using samples from December 2005 to February 2006 together with those from August 2006 to October 2006. The interim period from March 2006 to August 2006 is omitted from the sample. Since the sample periods include the periods when the QEP was and was not conducted, we need to use two distinct models. For the former period, we estimate the model of the policy commitment given by equation (2.11). For the latter period, we estimate the model without the policy commitment given by equation (B.1), although the effects of the policy commitment are considered to have remained as we stated in the above. In estimating the model, we employ a grid-search method with both π^c and π^0 in the range of –1.0 to 0.5 percent. For each π^c and π^0, we estimate α and β by restricting $\phi = (\beta - \alpha)/(\pi^c - \pi^0)$ from equation (B.3).

Table B-2 reports estimation results. Compared with Table 4, we find some differences, reflecting the rise in the policy rate in July 2006. Estimates α and β increase at all maturities. A difference of β from α widens significantly for three-month TIBOR. Slightly dissatisfactory results are the estimate of the threshold inflation rate π^c. Except for three-month TIBOR, the estimated threshold reaches 0.5 percent, the upper bound of grid search.[18] Having said, we still find a difference between $\pi^c$and π^0a useful indicator for the size of the policy commitment. The theory implies that the policy rate is raised at π^0 without the policy commitment, but that rise is delayed by $\pi^c - \pi^0$due to the policy commitment. For three-month TIBOR, the difference amounts to 0.8 percent point.

[18] We do not show here, but when we extend the upper bound to one percent, the estimated threshold reaches one percent.

B.3 Inflation Data

We next examine the effects of food and energy price changes. So far, we have focused the CPI excluding perishables, because that is the price index that the BOJ referred to during the QEP. The CPI includes food and energy prices, which are known to be volatile and transitory. One example is from 2007 to 2008, when global food and energy prices soared but soon dropped. In that respect, the CPI excluding food and energy serves as a good indicator for monetary policy decisions. Data on inflation expectations based on the CPI excluding food and energy are, however, not directly available. We thus calculate them by deducting the difference of actual inflation rates between the CPI excluding perishables and the CPI excluding food and energy from the data on inflation expectations.

Figures B-2 and B-3 plot interest rate expectations vis-a-vis inflation expectations under the QEP and after its exit, respectively. Compared with previous Figures 5 and 7, which were based on raw data on inflation expectations, differences are small. Quantitatively, however, Table B-3 reveals that the fit of the model worsens for the QEP period. For example, for two-year government bonds, adjusted R^2 decreases from 0.41 to 0.18. This result is consistent with the BOJ's announcement during the QEP, conditioning its policy on not the CPI excluding food and energy but the CPI excluding perishables. In the post period, changes in the fit of the model are mixed. At three-month and two-year maturities, adjusted R^2 decreases; at longer maturities, adjusted R^2 increases.

B.4 Model Specification

Next, we check robustness to model specification. We estimate four different models: (i) a simple model without a term structure consideration, (ii) a modified Tobit model, (iii) a model with policy inertia, and (iv) a model with the restriction of $\phi = 1.1$.

Model without Term Structure First, we estimate a simpler model than the benchmark by neglecting term structure. In the benchmark regression, we have matched time horizon between the expected interest rate as a dependent variable and the expected inflation rate as an independent variable. To this end, we have constructed an independent variable by combining inflation expectations data over different time horizons. However, inflation expectations over different time horizons are likely to obey different stochastic processes with different means and variances. That may cause a bias in our estimates. To examine robustness, in the regression here, we do not match time horizon between the expected interest rate as a dependent variable and the expected inflation rate as an independent variable. For the independent variable, we simply use directly available inflation expectations data: one-, two-, or ten-year inflation

expectations. We estimate the following simple model:

$$\begin{aligned} \mathrm{E}_t i^T_{t+k} = \alpha \left\{1 - I(\mathrm{E}_t \pi_{t+j} - \pi^c)\right\} \\ + I(\mathrm{E}_t \pi_{t+j} - \pi^c) \cdot \left\{\beta + \phi(\mathrm{E}_t \pi_{t+j} - \pi^c)\right\}. \end{aligned} \tag{B.4}$$

Table B-4 reveals that one-year inflation expectations are a good indicator for interest rate expectations. When using one-year inflation expectations as an explanatory variable, the results are very close to those we obtained in the benchmark estimation. When using inflation expectations over longer time horizon, the goodness of fit worsens. That suggests that when market participants forecast interest rates, they weigh their one-year inflation expectations rather than longer term inflation expectations.

Modified Tobit Model Second, we estimate a modified Tobit model. A standard Tobit model uses the data that have a clear lower bound, but in our dataset, observed interest rates are not strictly zero due to a term premium. We therefore predetermine a certain positive bound α. When a dependent variable is equal to or lower than α, we judge the data as being constrained by the bound. To see robustness, we try four values of α. A dependent variable is two-year government bond yields over three-month forecast horizon, and an independent variable is the inflation expectation over next one year.

Here is the Tobit model we use. We begin by neglecting additional non-linearity arising from the policy commitment. Regarding the policy rate described as

$$i^*_t = \gamma + \phi \pi_t + \varepsilon_t, \tag{B.5}$$

we assume that $\mathrm{E}^j_t[\varepsilon_{t+k}]$ obeys normal distribution with

$$\mathrm{E}_t \left[\mathrm{E}^j_t[\varepsilon_{t+k}]\right] = 0, \tag{B.6}$$

$$\mathrm{Var}_t \left[\mathrm{E}^j_t[\varepsilon_{t+k}]\right] = \sigma^2_\varepsilon. \tag{B.7}$$

The likelihood that $\mathrm{E}^j_t\left[i_{t+k}\right]$ equals zero is

$$\begin{aligned} P(E^j_t\left[i_{t+k}\right] = 0) \\ \equiv 1 - \left\{1 - \Phi\left(\frac{0 - \{\gamma + \phi \mathrm{E}^j_t\left[\pi_{t+k}\right]\}}{\sigma_\varepsilon}\right)\right\}. \end{aligned} \tag{B.8}$$

The likelihood that $\mathrm{E}^j_t\left[i_{t+k}\right]$ has a certain positive value is

$$\begin{aligned} P(E^j_t\left[i_{t+k}\right], E^j_t\left[i_{t+k}\right] > 0) \\ \equiv \frac{1}{\sigma_\varepsilon}\phi\left(\frac{E^j_t\left[i_{t+k}\right] - \{\gamma + \phi \mathrm{E}^j_t\left[\pi_{t+k}\right]\}}{\sigma_\varepsilon}\right). \end{aligned} \tag{B.9}$$

Summing up, log-likelihood is given by

$$LL \equiv \sum_j \log P(E_t^j [i_{t+k}] = 0) P(E_t^j [i_{t+k}], E_t^j [i_{t+k}] > 0). \tag{B.10}$$

In the presence of the term premium $\alpha > 0$, log-likelihood becomes

$$LL \equiv \sum_j \log P(E_t^j [i_{t+k}] < \alpha) P(E_t^j [i_{t+k}], E_t^j [i_{t+k}] > \alpha), \tag{B.11}$$

where the likelihood of $\mathrm{E}_t^j [i_{t+k}] = 0$ is transformed into

$$\begin{aligned} &P(E_t^j [i_{t+k}] = \alpha) \\ &\qquad \equiv 1 - \left\{ 1 - \Phi \left(\frac{\alpha - \{\gamma + \phi \mathrm{E}_t^j [\pi_{t+k}]\}}{\sigma_\varepsilon} \right) \right\} \end{aligned} \tag{B.12}$$

We search for $\{\sigma_\varepsilon^2, \gamma, \phi\}$ so as to maximize the above log-likelihood function. Note that the threshold inflation rate is given by $0 = \alpha - \{\gamma + \phi \pi^c\}$, that is

$$\pi^c = \frac{\alpha - \gamma}{\phi}. \tag{B.13}$$

Table B-5 generally confirms our benchmark results. For α around 0.15 percent, we obtain similar results. The threshold inflation rate is about zero percent. In other words, if the expected inflation rate is below zero percent, market participants anticipate that the interest rate continues to be α. If the expected inflation rate is above zero percent, market participants anticipate that the interest rate goes up above α. For reference, we also report the results when α is zero. Since all the interest rate forecasts are above zero, all the samples are categorized to uncensored. Consequently, the estimates are equivalent to those by the standard OLS method. That clearly creates a bias; for example, the estimated slope ϕ becomes lower.[19]

Model with Policy Inertia Third, we consider an inertial monetary policy rule. We consider a monetary policy rule with inertia as

$$i_t^* = \rho i_{t-1} + (1 - \rho) \{r^* + \pi^* + \phi(\pi_t - \pi^*)\}, \tag{B.14}$$

where ρ represents the degree of inertia. When ρ is zero, the policy rule has no inertia, and results are the same as those in the benchmark.

We here assume that the latent nominal interest rate i_t^* depends on the previous actual nominal interest rate i_{t-1}. As Reifschneider and Williams (2000) argue, it is probably more

[19] We also tried to estimate another Tobit model by taking account of uncertainty regarding a threshold inflation level. However, we could not find plausible results.

natural to assume that the latent nominal interest rate i_t^* depends on the previous latent nominal interest rate i_{t-1}^*. We, however, do not adopt the latter rule because it is empirically difficult to calculate i_{t-1}^*.

In a similar way to derive equation (2.11), we derive the following equation:

$$\begin{aligned}
\mathrm{E}_t i_{t+k}^T = & \frac{1}{T}\sum_{j=k}^{T+k-1} \alpha \left\{1 - I(\mathrm{E}_t\pi_{t+j} - \pi^c)\right\} \\
& + \frac{1}{T}\sum_{j=k}^{T+k-1} I(\mathrm{E}_t\pi_{t+j} - \pi^c) \\
& \cdot \left[\beta + \rho \mathrm{E}_t i_{t+j-1} + (1-\rho)\left\{r^* + \pi^* + \phi(\mathrm{E}_t\pi_{t+j} - \pi^c)\right\}\right], \qquad \text{(B.15)}
\end{aligned}$$

where $\beta = \alpha + (1-\rho)\{r^* + \pi^* - \phi(\pi^* - \pi^c)\}$. Due to the assumption of equation (2.5), we require $\beta > \alpha$. Using the expectations for interest rates and inflation rates at the previous period, the above equation is transformed into

$$\begin{aligned}
\mathrm{E}_t i_{t+k}^T = & \frac{1}{T}\sum_{j=k}^{T+k-1} \alpha \left\{1 - I(\mathrm{E}_{t-1}\pi_{t+j} - \pi^c)\right\} \\
& + \frac{1}{T}\sum_{j=k}^{T+k-1} I(\mathrm{E}_{t-1}\pi_{t+j} - \pi^c) \\
& \cdot \left[\beta + \rho \mathrm{E}_{t-1} i_{t+k-1}^T + (1-\rho)\left\{r^* + \pi^* + \phi(\mathrm{E}_{t-1}\pi_{t+j} - \pi^c)\right\}\right] \\
& + \mu_t, \qquad \text{(B.16)}
\end{aligned}$$

where a term μ_t is expressed as $(\mathrm{E}_t - \mathrm{E}_{t-1})$ of endogenous variables. In other words, μ_t represents unexpected changes in interest rates and inflation rates. When regressing the above equation, compared with the benchmark, we additionally use the lagged interest rate expectation, $\mathrm{E}_{t-1} i_{t+k-1}^T$, and replace $\mathrm{E}_t\pi_{t+j}$ by the lagged inflation expectation $\mathrm{E}_{t-1}\pi_{t+j}$. We do not use unobservable μ_t, but estimates are unbiased. This is because other explanatory variables are the expectations at the previous period $t-1$, which are uncorrelated with μ_t that is the surprise component from $t-1$ to t.

For comparison, we also estimate the model without the policy commitment:

$$\begin{aligned}
\mathrm{E}_t i_{t+k}^T = & \frac{1}{T}\sum_{j=k}^{T+k-1} \alpha \left\{1 - I(\mathrm{E}_{t-1}\pi_{t+j} - \pi^0)\right\} \\
& + \frac{1}{T}\sum_{j=k}^{T+k-1} I(\mathrm{E}_{t-1}\pi_{t+j} - \pi^0) \\
& \cdot \left[\alpha + \rho \mathrm{E}_{t-1} i_{t+j-1}^T + (1-\rho)\left\{r^* + \pi^* + \phi(\mathrm{E}_{t-1}\pi_{t+j} - \pi^0)\right\}\right] \\
& + \mu_t. \qquad \text{(B.17)}
\end{aligned}$$

Table B-6 supports our previous findings, although some of the results are inconsistent with model prediction. For two-year government bonds, for example, we obtain very high

policy inertia $\rho = 0.92$. The estimated slope ϕ is 1.03, which is above one and satisfies the Taylor principle. The threshold inflation rate π^c is -0.21 percent. It is slightly lower than 0.10 percent in the benchmark. A slightly unsatisfactory result is $\alpha > \beta$,suggesting a reduction in policy rates when the QEP ends. It may imply that the commitment effect to continuing low interest rates after the QEP was very strong. The threshold inflation rate π^0 is -0.50 percent, which is the minimum in our grid search. Adjusted R^2 is significantly lower according to the F test, suggesting the selection of the model with the policy commitment.

Model with the Restriction of $\phi = 1.1$ Fourth, we restrict the benchmark model with $\phi = 1.1$ so that it satisfies the Taylor principle.

As Table B-7 shows, parameter estimates are similar to those in the benchmark in most cases. β is greater than α at all the maturities; π^c is 0.14 percent for three-month TIBOR and 0.39 percent for two-year government bonds, in particular. The goodness of fit worsens significantly. At long maturities, adjusted R^2 is even negative, and π^c reaches 0.50, which is the maximum in our grid search.

B.5 Differences in Respondents

In the QSS survey, answers vary across respondents. Some respondents report high interest rate expectations, while others report low interest rate expectations. In Figure 5, for example, outliers are observed. Also, respondents belong to various institutions and are engaged in various jobs. Institutions are comprised of securities firms, banks, investment trusts, insurance firms, pension funds, other private financial institutions, and so on. Jobs are comprised of investment of their own funds, investment of pension funds, research, and so on.[20] Those differences possibly yield different answers.

To consider the effects of respondents' differences we employ pooled regression by dividing the sample by the type of respondents. Table B-8 reports estimates, showing that results are similar to those in the benchmark. The top table suggests that omitting outliers hardly changes our benchmark results. Here we examine the effects of outlier respondents by omitting the samples that are characterized by one-year inflation expectations lower than -1.5 percent or two-year interest rate expectations higher than 0.75 percent. Next, we divide sample by respondents' institutions and jobs. According to the middle and bottom tables, differences among respondents are small. In most cases, estimates are similar to those in the benchmark. The threshold inflation rate π^0 is zero percent or a little higher. The interest rate intercepts

[20] In those categories, we cannot tell whether respondents are bond traders or not.

α and β are positive, with β greater than α. The slope ϕ is positive except for investment advisories and pension management.

Table B-1: Estimation of models with and without the policy commitment

		α	β	ϕ	π^c	π^0	Adj R^2	F test
TIBOR	benchmark	0.093	0.095	0.249	-0.04	–	0.256	0.342
	w/o commit	0.093	$= \alpha$	0.259	–	-0.04	0.256	
	(S.E.)	0.001	–	0.009	–	–		
2Y	benchmark	0.118	0.287	0.153	0.10	–	0.413	0.000
	w/o commit	0.140	$= \alpha$	0.395	–	-0.05	0.350	
	(S.E.)	0.002	–	0.010	–	–		
5Y	benchmark	0.551	0.757	0.206	0.09	–	0.232	0.000
	w/o commit	0.643	$= \alpha$	0.346	–	0.00	0.198	
	(S.E.)	0.005	–	0.013	–	–		
10Y	benchmark	1.447	1.562	0.054	0.29	–	0.065	0.000
	w/o commit	1.479	$= \alpha$	0.115	–	0.00	0.055	
	(S.E.)	0.006	–	0.009	–	–		
20Y	benchmark	1.896	2.104	0.051	-0.20	–	0.035	0.000
	w/o commit	2.096	$= \alpha$	0.056	–	-0.20	0.030	
	(S.E.)	0.006	–	0.006	–	–		

Note: The sample period is July 2004 to February 2006. Dependent variables are forecasts over three-month forecast horizon.

Table B-2: Estimation for the sample periods that include three months just before and just after the QEP ended

		α	β	ϕ	π^c	π^0	Adj R^2	F test
TIBOR		0.152	0.302	0.193	0.32	-0.46	0.808	0.000
	(S.E.)	0.005	0.003	–				
2Y		0.349	0.733	0.493	0.50	-0.49	0.608	0.000
	(S.E.)	0.007	0.009	–				
5Y		0.923	1.179	0.328	0.50	-0.49	0.376	0.000
	(S.E.)	0.011	0.011	–				
10Y		1.579	1.707	0.164	0.50	-0.49	0.182	0.000
	(S.E.)	0.011	0.009	–				
20Y		2.116	2.180	0.081	0.50	-0.49	0.080	–
	(S.E.)	0.011	0.007	–				

Note: The sample period is December 2005 to February 2006 and August 2006 to October 2006. In the benchmark, we use the model with the policy commitment for the former period and the model without the policy commitment for the latter period. Dependent variables are forecasts over three-month forecast horizon.

Table B-3: Use of inflation expectations excluding food and energy

	Bench mark	Bench excl. F&E	Post	Post excl. F&E	Bench mark	Bench excl. F&E	Post	Post excl. F&E
	α				β			
TIBOR	0.093	0.101	0.852	0.818	0.095	0.117	0.680	0.707
2Y	0.118	0.163	0.958	0.720	0.287	0.287	0.763	0.910
5Y	0.551	0.675	1.290	1.049	0.757	0.789	1.243	1.309
10Y	1.447	1.512	1.713	1.534	1.562	1.566	1.703	1.796
20Y	1.896	2.123	2.113	2.171	2.104	2.165	2.202	2.230
	ϕ				π^c			
TIBOR	0.249	0.024	0.083	0.074	-0.04	-0.20	0.10	-0.22
2Y	0.153	0.074	-0.014	-0.003	0.10	-0.15	0.40	-0.34
5Y	0.206	0.136	-0.105	0.031	0.09	-0.07	0.40	-0.20
10Y	0.054	0.029	-0.059	-0.009	0.29	0.20	0.48	0.00
20Y	0.051	0.023	0.012	0.013	-0.20	0.30	0.22	0.11
	Adj R^2							
TIBOR	0.256	0.021	0.213	0.103				
2Y	0.413	0.180	0.185	0.173				
5Y	0.232	0.102	0.052	0.254				
10Y	0.065	0.017	0.019	0.275				
20Y	0.035	0.017	0.009	0.050				

Note: Dependent variables are forecasts over three-month forecast horizon.

Table B-4: Estimation without term structure consideration

	α	S.E.	β	S.E.	ϕ	S.E.	π^c	Adj R^2
– 1Y π^e as an explanatory variable –								
TIBOR	0.094	0.001	0.121	0.002	0.033	0.009	0.10	0.180
2Y	0.151	0.002	0.219	0.005	0.270	0.018	0.01	0.359
5Y	0.663	0.004	0.765	0.008	0.394	0.030	0.01	0.290
10Y	1.436	0.014	1.463	0.006	0.251	0.016	-0.25	0.089
20Y	2.074	0.013	2.124	0.006	0.094	0.016	-0.25	0.022
– 2Y π^e as an explanatory variable –								
TIBOR	0.062	0.007	0.082	0.002	0.037	0.002	-0.30	0.099
2Y	0.156	0.003	0.241	0.005	0.063	0.012	0.20	0.216
5Y	0.668	0.004	0.800	0.008	0.089	0.020	0.20	0.187
10Y	1.308	0.026	1.455	0.007	0.148	0.010	-0.30	0.083
20Y	1.951	0.024	2.106	0.006	0.087	0.010	-0.25	0.046
– 10Y π^e as an explanatory variable –								
TIBOR	0.094	0.002	0.100	0.001	0.006	0.001	0.40	0.015
2Y	0.176	0.004	0.197	0.004	0.025	0.005	0.50	0.033
5Y	0.689	0.007	0.739	0.007	0.035	0.007	0.50	0.038
10Y	1.498	0.006	1.534	0.006	0.028	0.007	0.50	0.027
20Y	2.114	0.005	2.142	0.006	0.031	0.006	0.50	0.029

Note: Dependent variables are forecasts over three-month forecast horizon.

Table B-5: Estimation of the Tobit model using 1Y π^e as an explanatory variable

	α (preset) [#N, #N]	γ	S.E.	ϕ	S.E.	σ_ε	S.E.	π^c= $(\alpha-\gamma)/\phi$
2Y	0 [0, 2096]	0.191	0.002	0.299	0.005	0.096	0.001	-0.64
	0.10 [413, 1683]	0.173	0.002	0.353	0.006	0.113	0.001	-0.21
	0.15 [919, 1177]	0.136	0.003	0.453	0.009	0.138	0.002	0.03
	0.20 [1242, 854]	0.100	0.005	0.575	0.017	0.150	0.003	0.17

Note: Two figures in a square bracket [,] indicate the number of samples where the dependent variable is equal or lower than α and higher than α, respectively. When α is zero, the esimation is equivalent to simple linear regression because all the dependent variables are above zero due to a term premium. Dependent variables are forecasts over three-month forecast horizon.

Table B-6: Estimation of models with policy inertia

		α	β	ϕ	ρ	π^c	π^0	Adj R^2	F test
TIBOR	w commit	0.088	0.019	0.288	0.728	-0.24		0.440	0.000
	(S.E.)	0.002	0.002	0.028	0.025				
	w/o commit	0.008	$= \alpha$	0.227	0.717	–	-0.48	0.434	
	(S.E.)	0.002	–	0.021	0.024	–	–		
2Y	w commit	0.111	0.007	1.026	0.922	-0.21		0.702	0.000
	(S.E.)	0.007	0.003	0.184	0.016				
	w/o commit	-0.012	$= \alpha$	0.857	0.913	–	-0.50	0.694	
	(S.E.)	0.004	–	0.135	0.016	–	–		
5Y	w commit	0.570	0.108	0.128	0.891	-0.01		0.642	0.000
	(S.E.)	0.010	0.012	0.110	0.016				
	w/o commit	0.108	$= \alpha$	0.306	0.804	–	-0.50	0.624	
	(S.E.)	0.010	–	0.046	0.014	–	–		
10Y	w commit	1.229	0.595	0.061	0.597	-0.21		0.448	0.000
	(S.E.)	0.035	0.022	0.017	0.014				
	w/o commit	0.658	$= \alpha$	0.058	0.549	–	-0.50	0.420	
	(S.E.)	0.021	–	0.015	0.014	–	–		
20Y	w commit	1.896	0.969	0.012	0.541	-0.21		0.361	0.000
	(S.E.)	0.043	0.032	0.011	0.015				
	w/o commit	1.207	$= \alpha$	0.010	0.430	–	-0.50	0.301	
	(S.E.)	0.029	–	0.009	0.014	–	–		

Note: Dependent variables are forecasts over three-month forecast horizon.

Table B-7: Estimation with restriction $\phi = 1.1$

		α	β	π^c	Adj R^2
TIBOR		0.099	0.199	0.14	0.117
	(S.E.)	0.001	0.003		
2Y		0.180	0.433	0.39	0.078
	(S.E.)	0.002	0.009		
5Y		0.704	1.359	0.50	-0.070
	(S.E.)	0.005	0.010		
10Y		1.558	2.695	0.50	-1.095
	(S.E.)	0.008	0.009		
20Y		2.176	3.713	0.50	-4.133
	(S.E.)	0.012	0.010		

Note: Dependent variables are forecasts over three-month forecast horizon.

Table B-8: Estimation omitting outliers and dividing respondents

	α	β	ϕ	π^c	Adj R^2	♯ N
Omitting Outliers						
2Y 3M	0.118	0.286	0.152	0.10	0.425	2,871
(S.E.)	0.003	0.005	0.019			

	α	β	ϕ	π^c	Adj R^2	♯ N
Institution						
Security Firm (domestic)	0.110	0.315	0.154	0.10	0.480	407
(S.E.)	0.008	0.014	0.053			
Security Firm (foreign)	0.125	0.249	0.293	0.09	0.494	151
(S.E.)	0.009	0.022	0.092			
Investment Trust	0.125	0.275	0.164	0.10	0.370	715
(S.E.)	0.006	0.012	0.041			
Investment Advisory	0.103	0.295	-0.033	0.12	0.217	126
(S.E.)	0.020	0.031	0.109			
Bank	0.114	0.287	0.110	0.10	0.415	809
(S.E.)	0.005	0.009	0.035			
Trust Bank	0.118	0.184	0.459	0.00	0.427	235
(S.E.)	0.014	0.020	0.071			
Insurance Firm	0.122	0.310	0.063	0.10	0.410	233
(S.E.)	0.009	0.018	0.062			

	α	β	ϕ	π^c	Adj R^2	♯ N
Job						
Treasury Management	0.118	0.282	0.152	0.10	0.403	958
(S.E.)	0.005	0.009	0.033			
Pension Management	0.129	0.378	-0.191	0.17	0.335	366
(S.E.)	0.007	0.020	0.075			
Research	0.112	0.261	0.189	0.09	0.461	260
(S.E.)	0.007	0.016	0.061			

Note: Dependent variables are forecasts of two-year bond over three-month forecast horizon, and ♯ N indicates the number of sample.

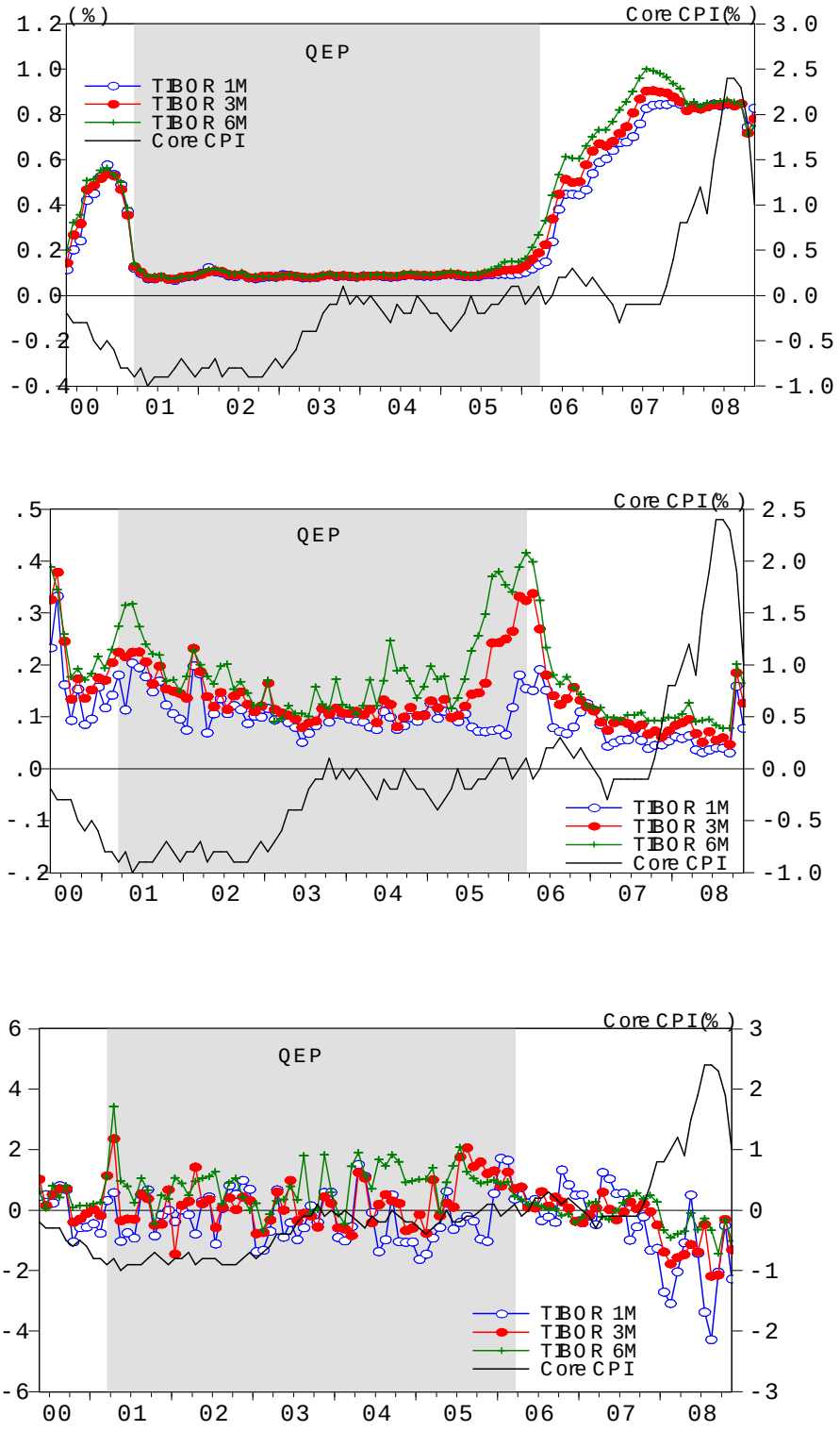

Figure A-1: Three-month TIBOR rate expectations (top: means; middle: standard deviations / means; bottom: skewness)

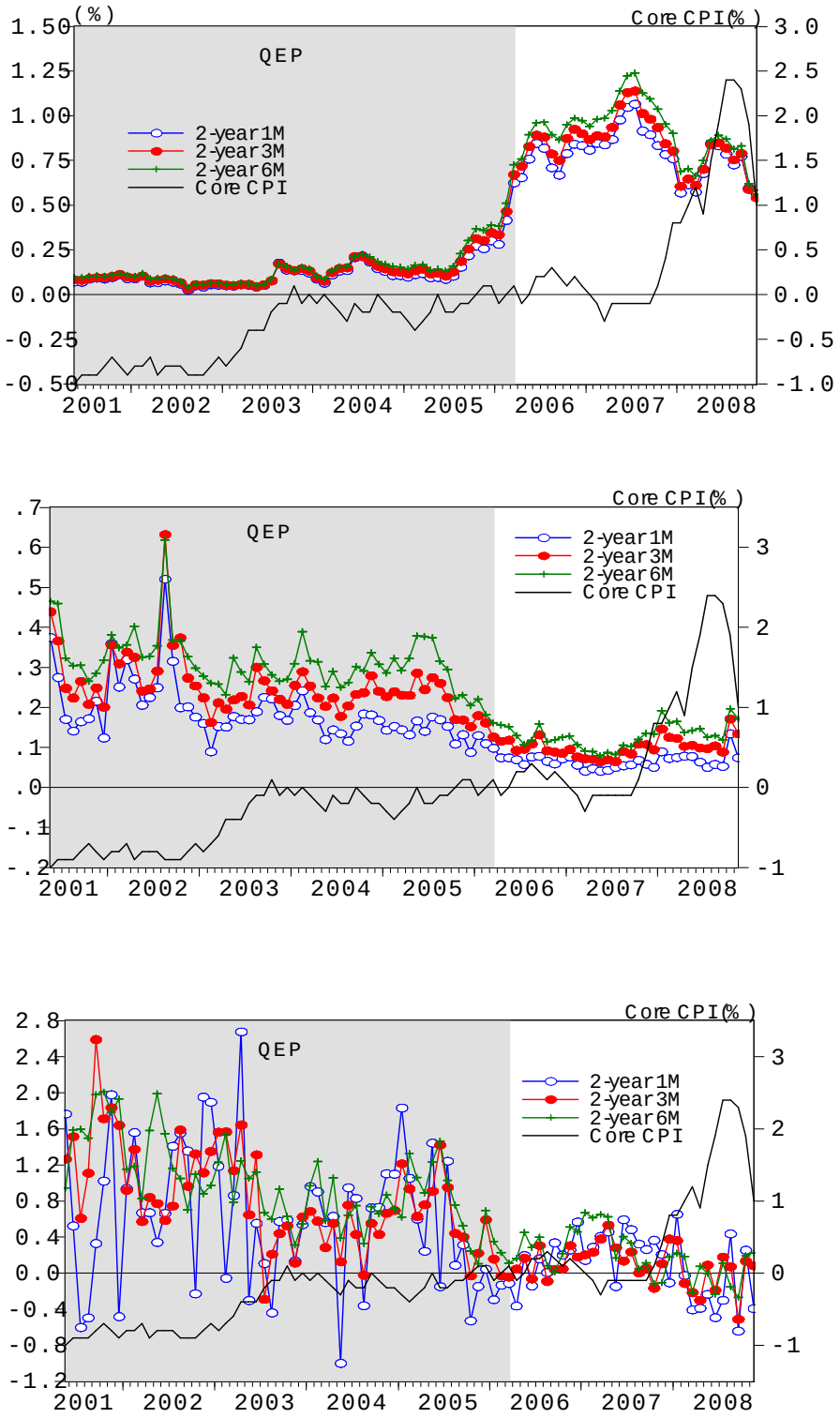

Figure A-2: Two-year JGB rate expectations (top: means; middle: standard deviations / means; bottom: skewness)

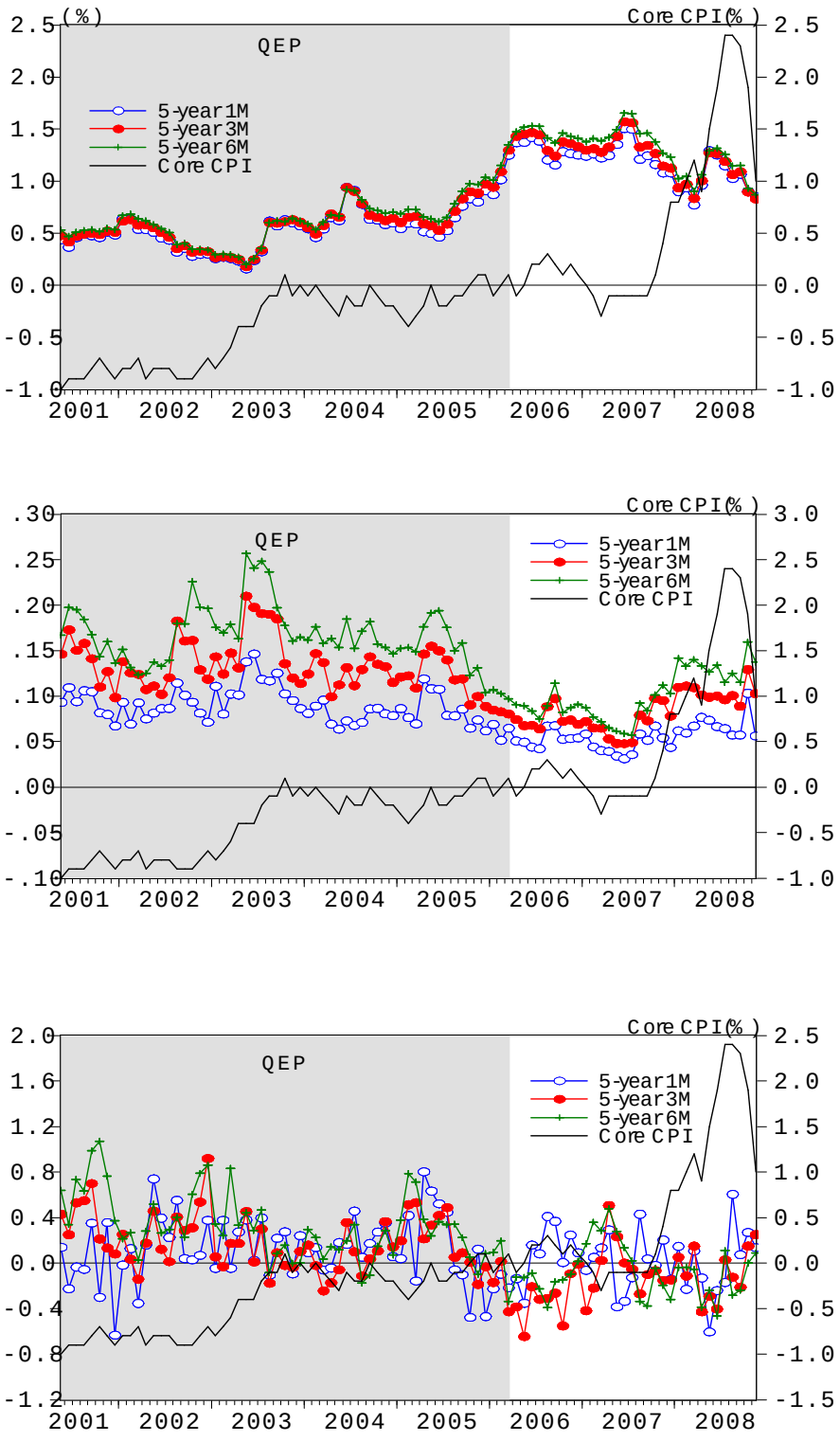

Figure A-3: Five-year JGB rate expectations (top: means; middle: standard deviations / means; bottom: skewness)

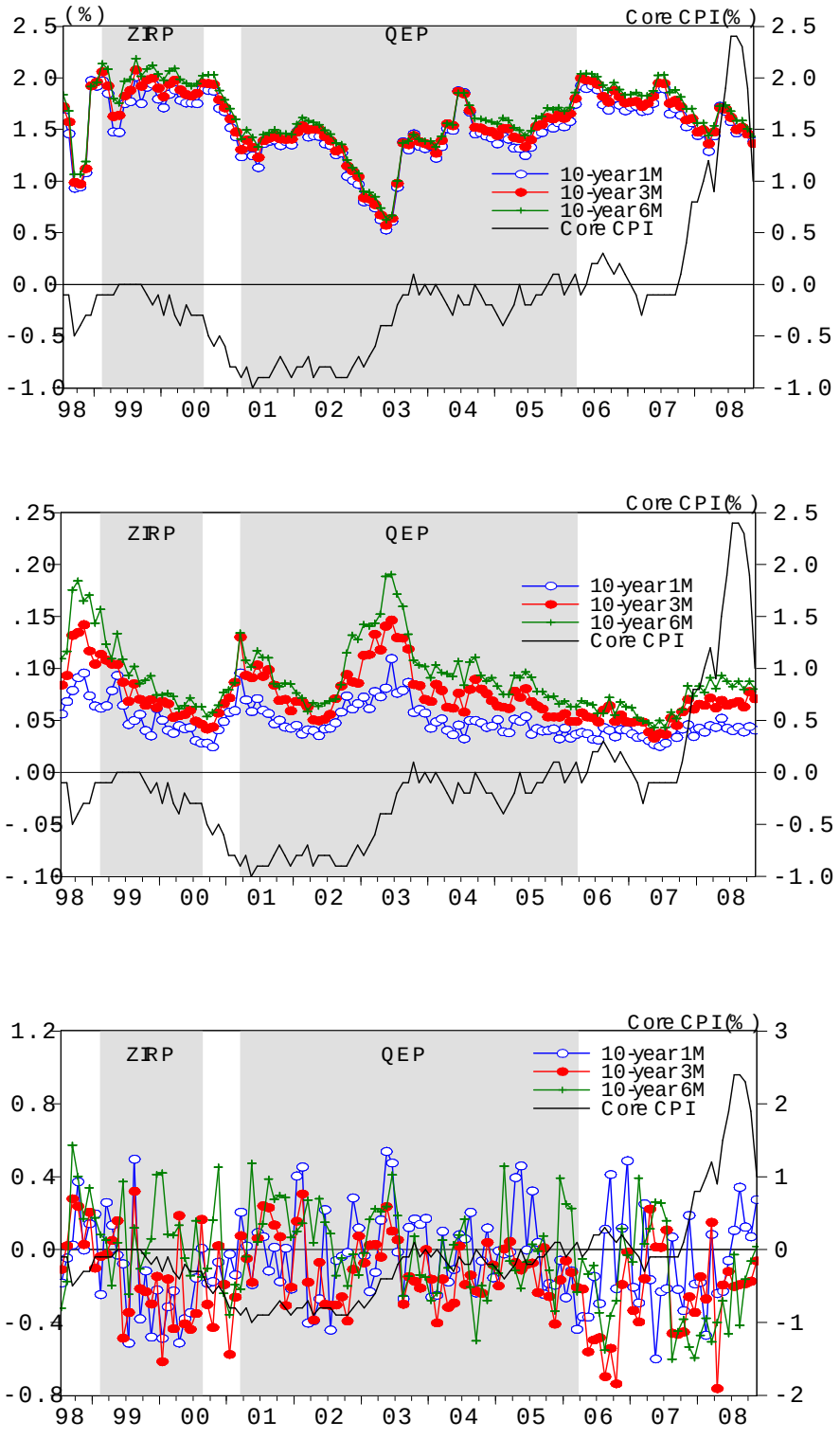

Figure A-4: Ten-year JGB rate expectations (top: means; middle: standard deviations / means; bottom: skewness)

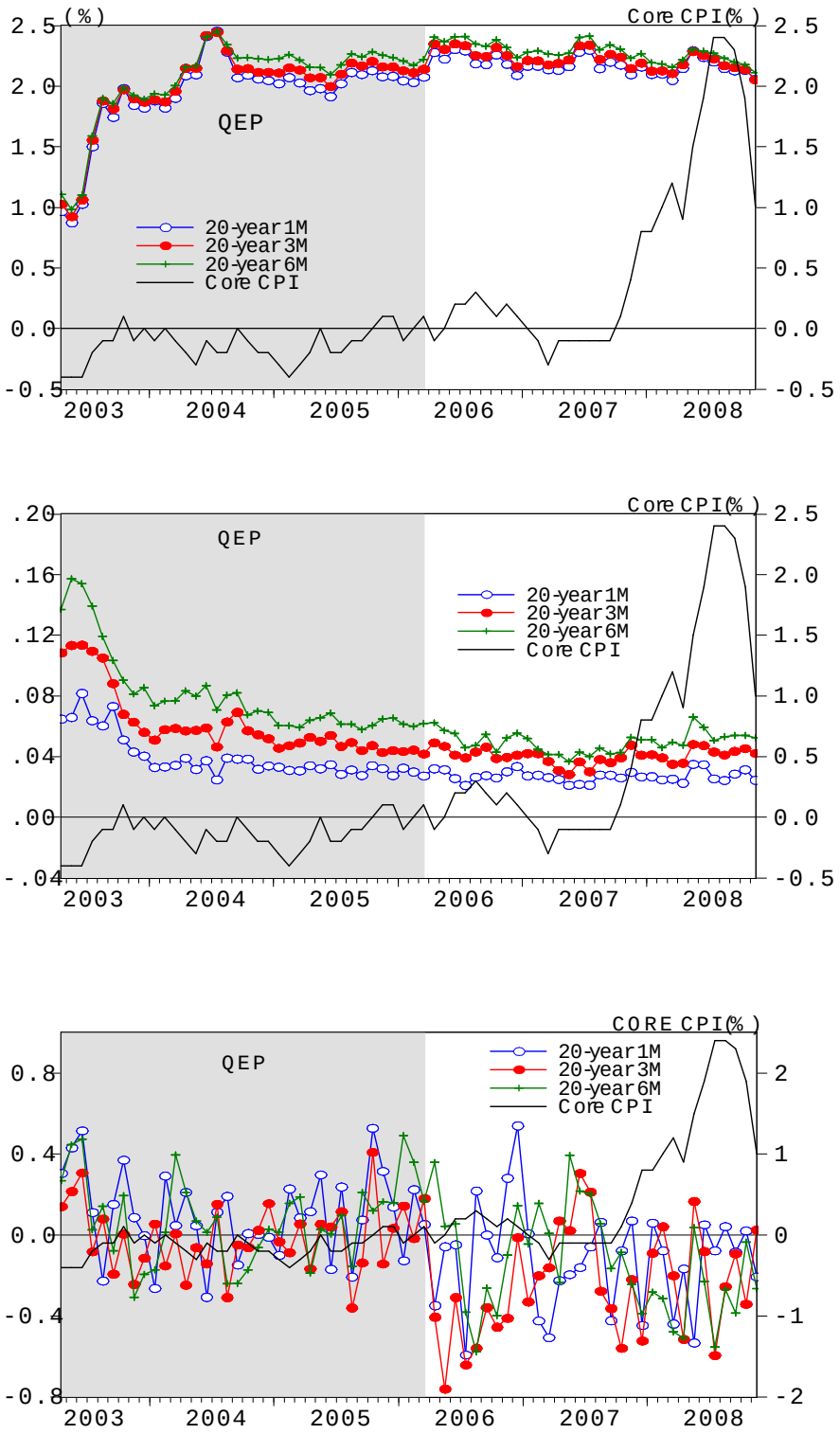

Figure A-5: 20-year JGB rate expectations (top: means; middle: standard deviations / means; bottom: skewness)

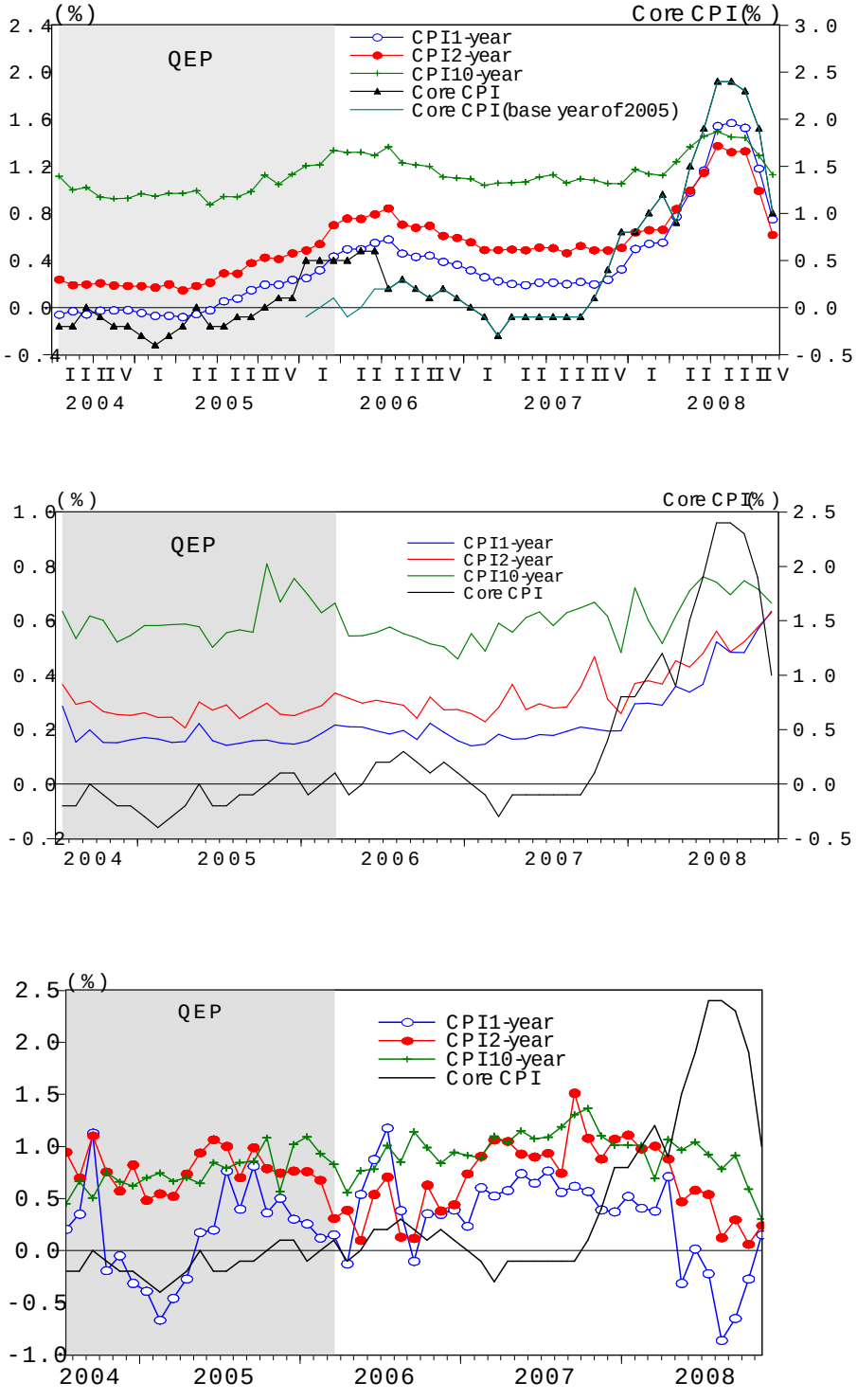

Figure A-6: Inflation expectations (top: means; middle: standard deviations; bottom: skewness)

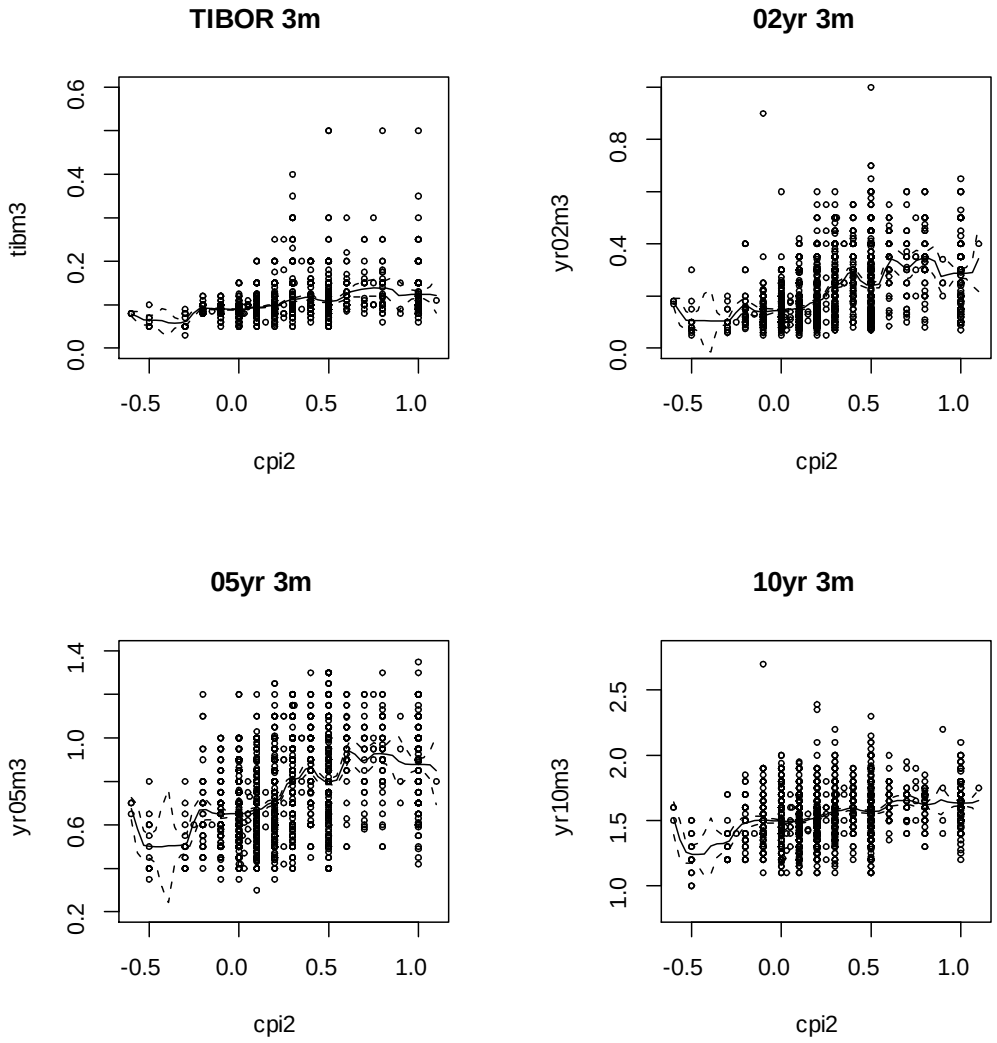

Figure A-7: Interest rate expectations vis-a-vis two-year inflation expectations

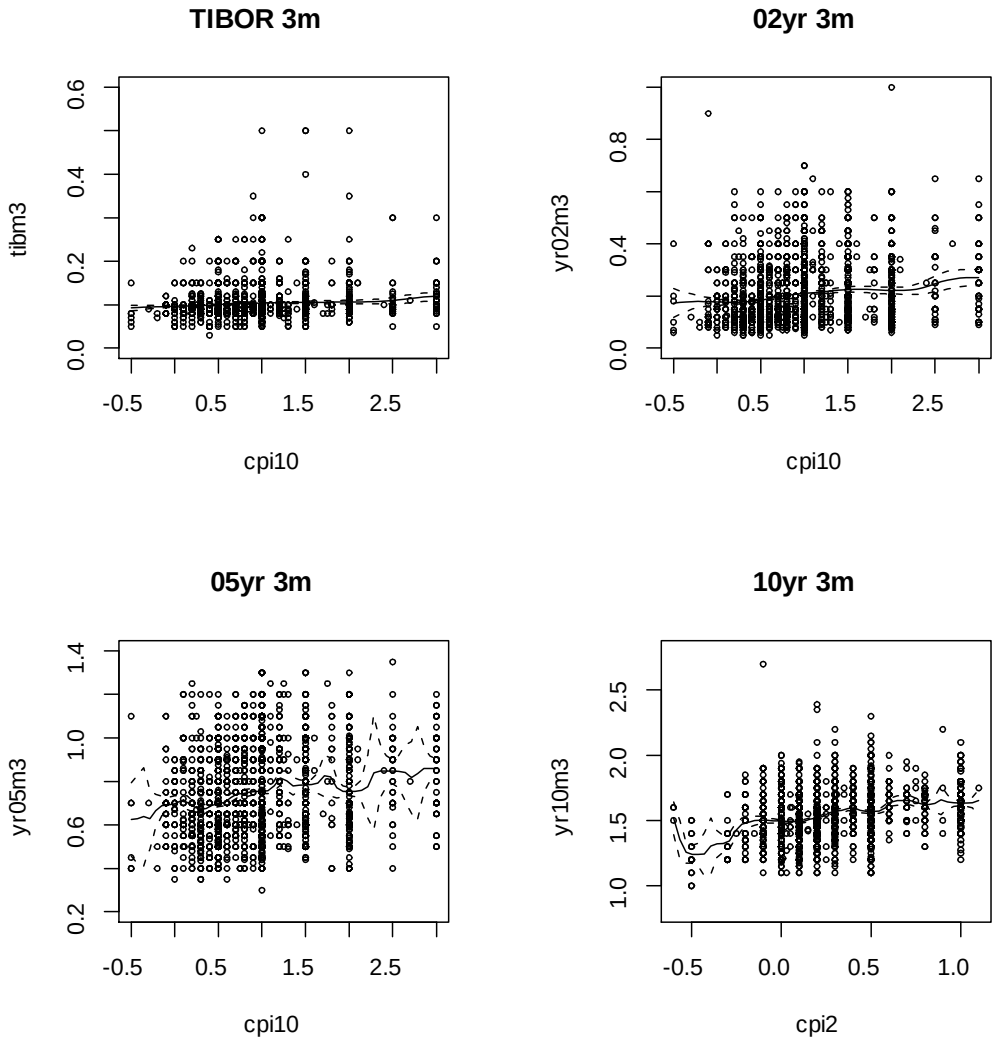

Figure A-8: Interest rate expectations vis-a-vis ten-year inflation expectations

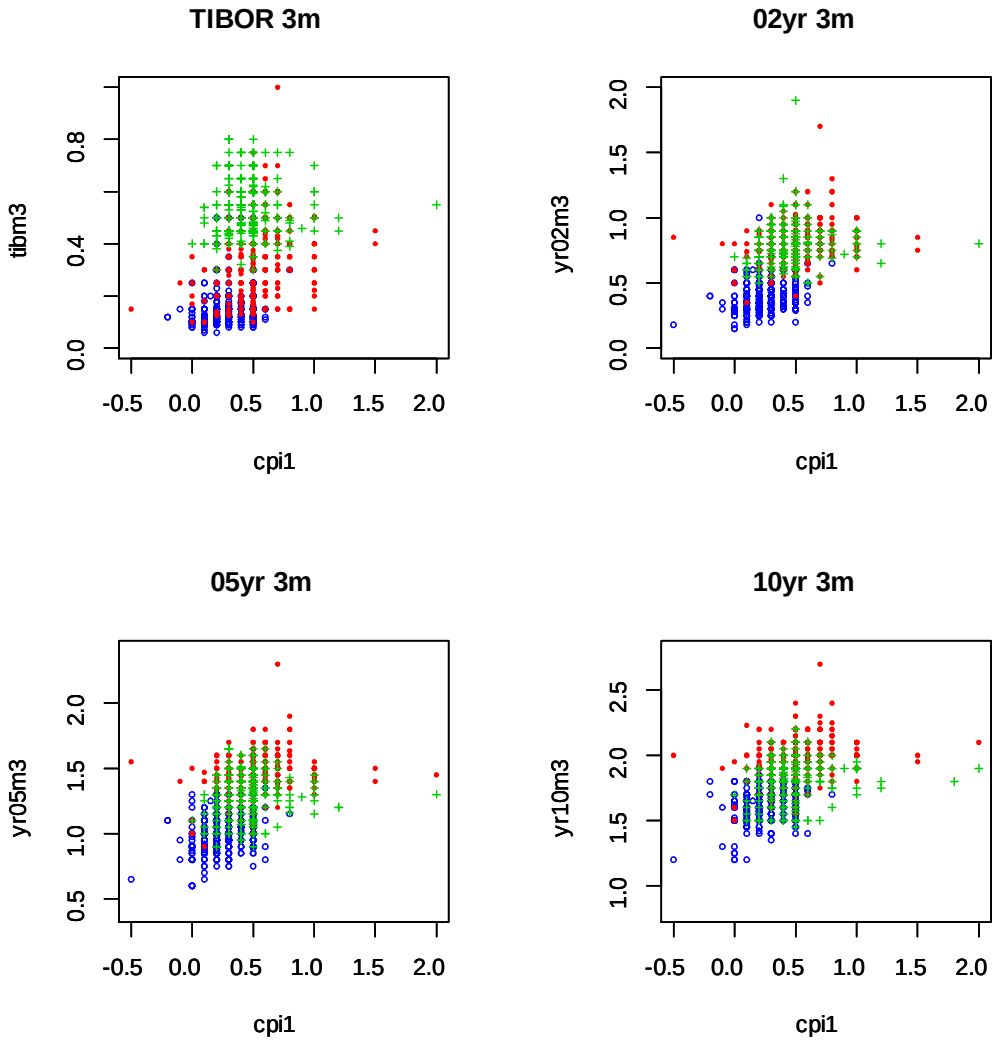

Figure B-1: Interest rate expectations vis-a-vis one-year inflation expectations in the short period just before and just after the QEP ended

Note: A blue circle (o) indicates a sample from December 2005 to February 2006, a red dot (·) indicates a sample from April 2006 to June 2006, and a green plus (+) indicates a sample from August 2006 to October 2006.

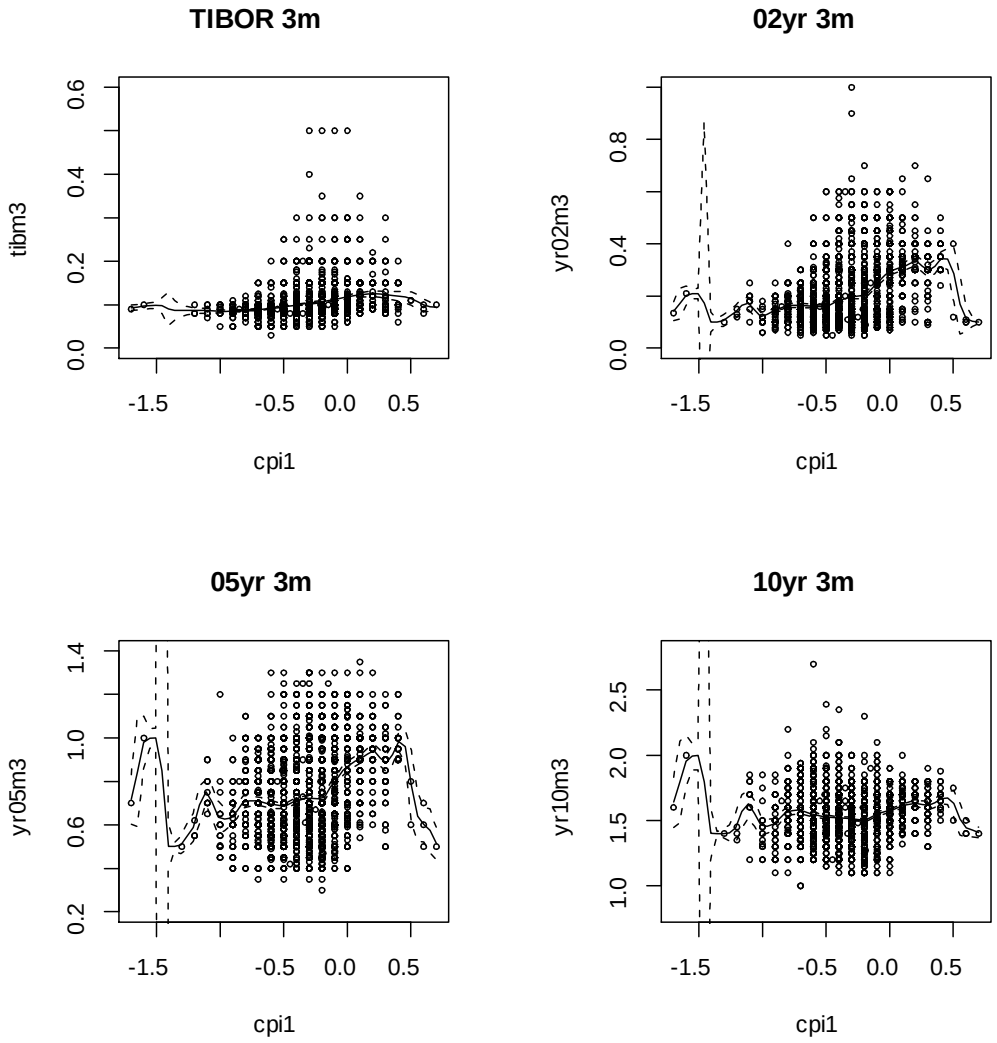

Figure B-2: Interest rate expectations vis-a-vis one-year inflation expectations excluding food and energy during the QEP

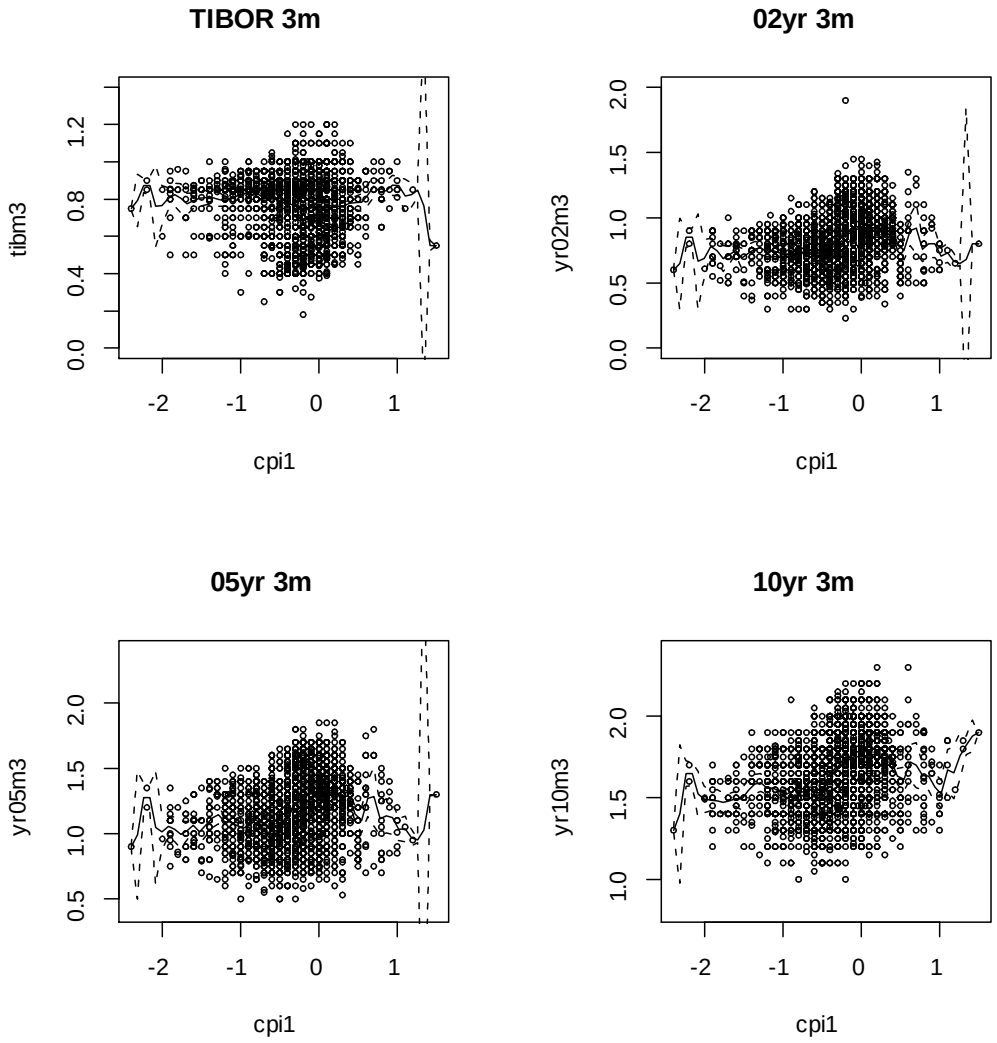

Figure B-3: Interest rate expectations vis-a-vis one-year inflation expectations excluding food and energy after the QEP ended