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Monetary Policy and the Yield Curve in Japan: VAR Approach with Sign Restrictions

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Abstract

We examine the effects of a monetary policy shock to the yield curve in Japan and investigate whether there are any differences of the effects between before and after the introduction of the zero interest rate policy (ZIRP) conducted by the Bank of Japan in February 1999 through VAR with sign restrictions. Our first finding is that long-term interest rates are significantly affected by the monetary policy shock. This result is different from that in Evans and Marshall (1998) which show that long-term rates are virtually unaffected by the shock. Second, the effects of the monetary policy shock on the yield curve are long-lasted for about 1 year. Finally, the responses of the yield curve depend on the samples; a surprise tightening in monetary policy lowers the interest rates before the introduction of the ZIRP, while the shock shifts the yield curve upward during the ZIRP period.

JEL Classification: C32; E43; E44; E52

Keywords: monetary policy; term structure of interest rates; VAR with sign restrictions.

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1 Introduction

The relationship between monetary policy and term structure of interest rate is not clear. There are two distinct maintained hypotheses about monetary policy shocks to nominal yield curve. One of them is the liquidity effect hypothesis maintaining that a surprise tightening in monetary policy increases short-term nominal interest rates, and decreases output, prices, and monetary aggregates. The liquidity effect hypothesis reflects the consensus view about how monetary policy affects the economy in the United States [1]. The other hypothesis is the costly price adjustment hypothesis maintaining that a contractionary monetary policy shock decreases interest rates, money supply, output and prices. This hypothesis is supported by the implications of monopolistic competition as in Rotemberg (1996), Christiano, Eichenbaum, and Evans (1999), Ireland (1997), and Aiyagari and Braun (1998). Braun and Shioji (2006) find that Japanese data from October 1987 through May 1999 are more consistent with the costly price adjustment hypothesis. Because we have no consensus on how monetary policy affects the yield curve and which hypothesis is better, we are interested in how monetary policy contributes to movements in the yield curve.

In order to clarify the relationship between monetary policy and the term structure of interest rates in Japan, we examine the effects of a monetary policy shock to the yield curve. Our motivation in this paper is related to the following three questions. The first question is whether monetary policy can affect the Japanese yield curve, especially longer-term interest rates. Evans and Marshall (1998) show that a contractionary monetary policy shock has the effects on the shorter-term interest rates using the data in the United States. Moreover, Evans and Marshall (1998) report that long-term rates are virtually unaffected by the shock. As for the Japanese data, Braun and Shioji (2006) find that a surprise tightening in monetary policy lowers interest rates, although they investigate only the short- and medium-term rates. We do not have enough empirical studies about the effects of a monetary policy shock to interest rates for now, especially longer-term rates.

[1] See Christiano, Eichenbaum, and Evans (1999).

The second question is how long the effects of monetary policy can last and how large they are. Evans and Marshall (1998) show that the effects on the shorter-term interest rates have only a transitory effect and are short-lived: the effects of the shock last only for about 6 months. Braun and Shioji (2006) find that under the costly price adjustment hypothesis, a surprise tightening in monetary policy lowers interest rates by up to 20 basis points and it pushes down the yield curve below zero significantly for about 1 year. However, neither Evans and Marshall (1998) nor Braun and Shioji (2006) investigate the contribution of the shock to longer-term interest rates like 10-year bond.

The last question is whether the zero lower bound on nominal interest rates in Japan affects the effects of the shock to interest rates or not. In February 1999, the Bank of Japan introduced the unprecedented monetary policy called as zero interest rates policy (ZIRP), which keeps the overnight call rate almost near zero percent. There are a lot of arguments about the effects of the ZIRP, but what we want to investigate is whether the transmission mechanism of monetary policy to the yield curve has changed or not since the Bank of Japan started to conduct the ZIRP. Braun and Shioji (2006) imply that the mechanism of the monetary policy shock to interest rates follows the costly price adjustment hypothesis before the ZIRP started. However, we do not know what has happened during the ZIRP period and whether the transmission mechanism may have changed since the Bank of Japan introduced the unprecedented policy in February 1999.

In order to answer the three questions, we use the vector autoregression (VAR) with sign restrictions and find the following three points. First, the monetary policy shock has the significant effects on the interest rates: the shock affects not only the short- and medium-term interest rates but also the long-term interest rates during both of the pre-ZIRP and the ZIRP period. Second, we show that the effects of the monetary policy shock are longer-lasted for 1 year than as those of Evans and Marshall (1998) and stronger on the shorter-term interest rates than on the longer-term interest rates. Finally, we find that the divided samples, that is, before and after the introduction of the ZIRP, bring us the contrast results; a surprise tightening in monetary policy lowers all of the yield significantly during the pre-

ZIRP period, however, the shock shifts the yield curve upward significantly during the ZIRP period. Our main results are supported by the robustness check.

In sum, our findings contrast to past studies and interesting. First, Monetary policy unambiguously has some impacts on long-term interest rates. Our estimation results show that not only short-term but also long-term interest rates are significantly affected by the monetary policy shock although literature reports that long-term rates are virtually unaffected. Evans and Marshall (1998) conclude that a contractionary policy shock induces a transitory response in short-term interest rates, with a smaller effect on medium-term rates and almost no effect on long-term rates in the case of the United States.

Second, we reveal that the surprise tightening in monetary policy has the longer-lasted effects on all of the yields for about 1 year and the stronger effects especially on the short- and medium-term interest rates.

Finally, the transmission mechanism of monetary policy to the yield curve has changed since the Bank of Japan started to conduct the ZIRP. In ‘normal’ economic situation, our estimation results are consistent with the costly price adjustment hypothesis. In fact, our results show the decline of the yield curve in response to the monetary policy shock during the pre-ZIRP period as is the case with Braun and Shioji (2006). However, once the Japanese economy has fallen into deflation, the responses of the interest rates to the shock are completely different from the costly price adjustment hypothesis: after the introduction of the unprecedented policy in 1999, the responses of nominal yield curve to the unexpected tightening in monetary policy follow the liquidity effect hypothesis rather than the costly price adjustment hypothesis.

This paper is structured as follows. In Section 2, we provide the VAR framework with sign restrictions to examine the relationship between monetary policy and the term structure of interest rate. In Section 3, we show the estimation results of our model and in Section 4, we discuss the estimation results. Section 5 concludes.

2 Estimation

2.1 Data

A set of monthly data consists of seven endogenous and five exogenous variables. The endogenous variables include industrial production (ip), the year-on-year rate of change in the CPI excluding perishables (p), uncollateralized overnight call rate ($call$), and exchange rate for the yen against the dollar as macroeconomic variables (fx) as a set of macroeconomic variables Y and Japanese Government Bond yields of 1-year ($y1$), 5-year ($y5$), 10-year ($y10$) as a set of interest rates, R. The exogenous variables include industrial production in the United States (ip_{us}) and oil price in terms of the dollar (oil) as a set of macroeconomic variables in foreign sector, X and Treasury yields of 1-year ($us1$), 5-year ($us5$), 10-year ($us10$) as a set of interest rates in foreign sector, Z. The endogenous and exogenous variables are all expressed by the change rates of levels with the exception of R and Z. In sum, Y, R, X, and Z are the following vectors:

$$Y_t \equiv \begin{pmatrix} ip_t \\ p_t \\ call_t \\ fx_t \end{pmatrix}, \quad R_t \equiv \begin{pmatrix} y1_t \\ y5_t \\ y10_t \end{pmatrix}, \quad X_t \equiv \begin{pmatrix} ip\_us_t \\ oil_t \end{pmatrix}, \text{and} \quad Z_t \equiv \begin{pmatrix} us1_t \\ us5_t \\ us10_t \end{pmatrix}.$$

Our model uses the foreign exchange rate instead of the monetary base. The economic growth of Japan's economy highly depends on the performance of the export sector which is strongly affected by the exchange rate. On the other hand, the monetary base has played a less role on the Japanese economy according to Miyao (2005) reporting that the linkage between the money supply and income or prices has largely disappeared since the late 1990s[2].

[2] Miyao (2005) suggests that nonperforming loans problems and restructuring may be root causes of his findings and says that the Bank of Japan has reported the "money supply forecast" since the late 1970s, but it has never been used formally as an intermediate target.

We use the following structural vector autoregression framework for our analysis:

$$\begin{pmatrix} a & b \\ c & 1 \end{pmatrix} \begin{pmatrix} Y_t \\ R_t \end{pmatrix} = \begin{pmatrix} A(L) & B(L) \\ C(L) & D(L) \end{pmatrix} \begin{pmatrix} Y_{t-1} \\ R_{t-1} \end{pmatrix} + \begin{pmatrix} E(L) & F(L) \\ G(L) & H(L) \end{pmatrix} \begin{pmatrix} X_t \\ Z_t \end{pmatrix} + \sigma \begin{pmatrix} \varepsilon_t^Y \\ \varepsilon_t^R \end{pmatrix},$$

where a is a 4 x 4 matrix with ones on the diagonal; b is 4 x 3 matrix; c is a 3 x 4 matrix; $A(L)$, $B(L)$, $C(L)$, $D(L)$, $E(L)$, $F(L)$, $G(L)$, and $H(L)$ are matrix polynomials in the lag operator L. The shock $[\varepsilon_t^Y \varepsilon_t^R]'$ is an i.i.d, vector of mutually and serially uncorrelated structural shocks whose variance is the identity matrix.

As we follow the strategy of Evans and Marshall (1998), we maintain the assumptions that $b = B(L) = F(L) = G(L) = 0$:

$$\begin{pmatrix} a & 0 \\ c & 1 \end{pmatrix} \begin{pmatrix} Y_t \\ R_t \end{pmatrix} = \begin{pmatrix} A(L) & 0 \\ C(L) & D(L) \end{pmatrix} \begin{pmatrix} Y_{t-1} \\ R_{t-1} \end{pmatrix} + \begin{pmatrix} E(L) & 0 \\ 0 & H(L) \end{pmatrix} \begin{pmatrix} X_t \\ Z_t \end{pmatrix} + \sigma \begin{pmatrix} \varepsilon_t^Y \\ \varepsilon_t^R \end{pmatrix}, \qquad (1)$$

indicating that while Y_t is affected only by its own lagged variables and X_t, a set of interest rates, R, responds contemporaneously to the all endogenous variables and is affected by a set of lagged interest rates in the United States.

In addition, we impose another assumption on this structural VAR in order to construct a parsimonious model. We exclude the lagged variables of call rate ($call$) whose lags are longer than one, that is, Y_t and R_t are not affect by $call_{t-n}$ for $n \geq 2$.

In order to impose sign restrictions on impulse responses similarly to Uhlig (2005), our main estimation strategy includes bootstrapping method to generate resampled data[3]. First, we estimate equation(1) and acquire residuals. Then, we reorder them randomly and generate resampled data with estimated parameters and reordered residuals. Finally, we re-estimate equation(1) using the resampled data. We continue this process until we acquire

[3] See, Evans and Marshall (1998), Mittnik and Zadrozny (1993), Kilian (1998a), Kilian (1998b).

10,000 impulse responses using the following sign-restrictions method.

We impose sign restrictions on impulse responses in order to ensure that our estimation results are consistent with economic theory[4]. Economic theory suggests that the contractionary monetary policy shocks has negative impacts on output for a certain period N. In our case, N is set to 6 because past empirical studies generally assume that N should be about 6 [5]. It means that the responses of industrial production are all negative in the first 6 months following the arrival of a contractionary monetary policy shock.

In order to investigate whether there are any differences of the effects of monetary policy shocks between the pre-ZIRP period and the ZIRP period, we divide the sample period into two: sub-period 1 and sub-period 2. The sub-period 1 and sub-period 2 cover the pre-ZIRP period from July 1985 to December 1998 and the ZIRP period from January 1999 to December 2009, respectively. We estimate the model using two sub-samples separately and compare two estimation results.

3 Estimation Results

In this section, we show our impulse responses acquired by the sign restrictions.

3.1 Main Result

We estimate structural VAR using the two sample: sub-period 1 and sub-period 2. Figure 1 and 2 show impulse responses to a contractionary monetary policy shock.

[4]For example, Braun and Shioji (2006), Canova and Nicoló (2002), Faust (1998), Mountford (2005), and Uhlig (2005) analyze monetary policy utilizing the sign-restrictions method.

[5]Applications of the sign-restrictions method have been growing. For example, Uhlig (2005) uses the sign restriction approach with $N = 6$ and suggests that the assumption is “reasonable” in that the estimation results confirm conventional economic principles. Braun and Shioji (2006) also impose the sign restrictions on VAR analyzing the Japanese data and they set N to 6 or 7. In Braun and Shioji (2006), $N = 6$ when the restrictions are imposed on monetary base and interest rates, and $N = 7$ when the restrictions are imposed on price and output.

Figure 1 illustrates the responses of interest rates to monetary policy shock and shows two points. First, the left panel in Figure 1 shows negative responses to the contractionary monetary policy shock for about 1 year, while the right panel presents positive responses to the shock for about 1 year. In sub-period 1, a contractionary monetary policy shock decreases all of yields, 1-year, 5-year, and even 10-year interest rates, significantly. The dashed lines, presenting one sigma fluctuations fall below zero in the left panel. In contrast to the sub-period-1, the right panel shows positive responses to the shock. All of the yields increase initially in response to the contractionary monetary policy shock. These responses are a little weaker than those of the left panel, but they all are positive significantly. The results are clearly opposite between two periods.

Second, there are larger responses of shorter-term interest rates than that of longer-term interest rate in both periods. In both panels, the bottoms and peaks are larger in 1-year and 5-year yields than those of 10-year yield. The left panel shows that responses of short- and middle-term interest rates drop below -0.1% in forth month, while that of long-term interest rate does not reach at -0.1% on average. Similarly, in sub-period 2 the shorter-term yields move positively more than the longer-term interest rate in response to the initial shock. The monetary policy shock affects the shorter-term yields more than the longer-term yield in the both periods.

In Figure 2, we illustrate the impulse responses of macroeconomic variables to monetary policy shock and find three things. First, the responses of output to contractionary monetary policy shock decrease significantly in both panels. While the response in the left panel is a little weak, the dashed lines fall below zero significantly.

Second, there is a difference in price change to monetary policy shock between two panels. The left panel illustrates the initial drop of the response of price to the shock, while the right one shows that price positively responds to the shock. The important finding is that during the pre-ZIRP period, price falls sticky along with the decline of output.

Finally, Figure 2 shows that the call rates are downward-sloping. The responses of the call rate are initially positive and decay over time. The response in sub-period 2 is weak, but it decreases gradually like that of the left panel, indicating that the monetary policy shocks in both panels are well identified.

3.2 Robustness Check

The robustness to our estimation results is checked and our estimation results are supported by the robustness check.

Figure 3 and 4 show the responses to the monetary policy shock when exogenous variables, X and Z, are excluded from our model. The left panel in Figure 3 presents the responses during the pre-ZIRP period and shows that all of interest rates fall in response to the contractionary monetary policy shock, which is similar to those in Figure 1[6]. In the right panel showing the responses during the ZIRP period, all of the responses of 1-year, 5-year, and 10-year yields are significantly affected by the shock in the right panel. These contrast results are similar to those of the model with exogenous variables in Figure 1.

The impulse responses in Figure 4 are also similar to those in Figure 2. Output responds negatively in the both periods, while that of the left panel is weaker than that of the right one. Price drops significantly only in the left panel, indicating that monetary policy shock decreases price during the pre-ZIRP period.

4 Discussion

Our estimation results clearly contrast between the pre-ZIRP and the ZIRP period. It is interesting to see that the divided samples bring us the contrast results; a surprise tightening in monetary policy lowers both of the shorter- and the longer-term interest rates significantly in sub-period 1, while the shock shifts the yield curve rates upward significantly in sub-period 2. In other words, the results during the pre-ZIRP period are consistent with the

[6]The response of 10-year bond in the left panel is significantly positive in one year after the shock. However, the 10-year interest rate is initially pushed down below zero by the contractionary shock as is the case with the shorter-term bond yields.

costly price adjustment hypothesis, while the results during the ZIRP period are consistent with the liquidity effect hypothesis.

More interestingly, in both periods, the long-term interest rates are significantly affected by the shock of monetary policy. In response to a contractionary monetary policy shock, the yield on 10-year significantly decreases for about 1 year during the pre-ZIRP period and significantly increases for about 1 year during the ZIRP period. These results are different from those in Evans and Marshall (1998), which report that long-term rates are virtually unaffected by the shock and the liquidity effects are short-lived and last for only 6 months.

Then, why are the estimation results clearly opposite between the two periods? Our answer to this question comes from the change of the perception of market participants about the monetary policy shock. As we mentioned above, in sub-period 1, a surprise tightening in monetary policy decreases all of the yields significantly as bond investors believe that the shock lowers interest rates, lowers output, and lowers prices. However, the yields on 1-year, 5-year, and 10-year subsequently rise significantly during the ZIRP period as bond investors become more optimistic about economic growth in response to the monetary policy shock. In other words, while based on the costly price adjustment hypothesis the unexpected rise in the policy rate drop all of the yields significantly during the pre-ZIRP period, market participants may consider the contractionary monetary policy shock as the positive signal to the economic recovery of Japan during the ZIRP period. This change of the perception of market participants about the shock of monetary policy contributes to explaining the reason why the responses of all yields to the shock are significantly positive in sub-period 2.

5 Conclusion

We examine the effects of a monetary policy shock to the yield curve and whether there are any differences of the effects during the pre-ZIRP and the ZIRP period in Japan through the vector autoregression with sign restrictions. Our contributions to the literature are the following three points. First, during both periods, long-term interest rates are significantly affected by the shock of monetary policy in response to a contractionary monetary policy shock and these results are different from those in Evans and Marshall (1998), which report that long-term rates are virtually unaffected by the shock. Second, the effects of the monetary policy shock are long-lasted for about 1 year and stronger effects on the short- and medium term interest rates than the long-term interest rate. Finally, we find that the divided samples bring us the contrast results; a surprise tightening in monetary policy lowers shorter- and longer-term interest rates significantly during the pre-ZIRP period, while the shock shifts the yield curve upward significantly during the ZIRP period.

We reveal the contributions of monetary policy to the yield curve and find the interesting results. Yet, there are some questions left. For example, why has the transmission mechanism of monetary policy to the yield curve changed over time? It is likely to say that the reason why the transmission mechanism has changed is partly because bond investors have changed their expectations on the future path of short-term interest rates after the introduction of the unprecedented ZIRP. We have not investigated the structural reason behind this question. Structural understanding of this is left for our future research.

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Figure 1: Responses of interest rates to monetary policy shocks. The left panel covers the pre-ZIRP period and the right one covers the ZIRP period from 1996 to 2009.

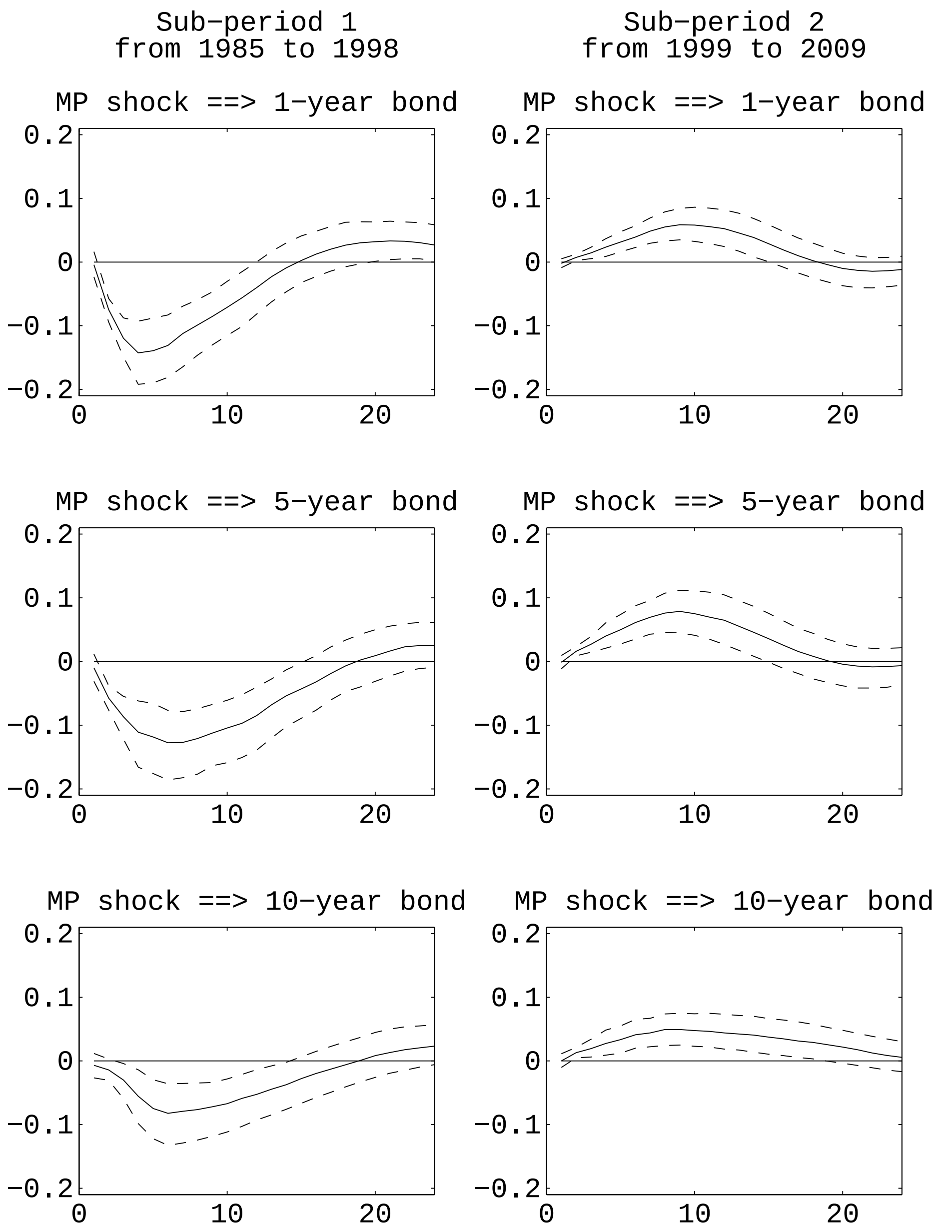

Figure 2: Responses of macroeconomic variables to monetary policy shocks. The left panel covers the pre-ZIRP period and the right one covers the ZIRP period from 1996 to 2009.

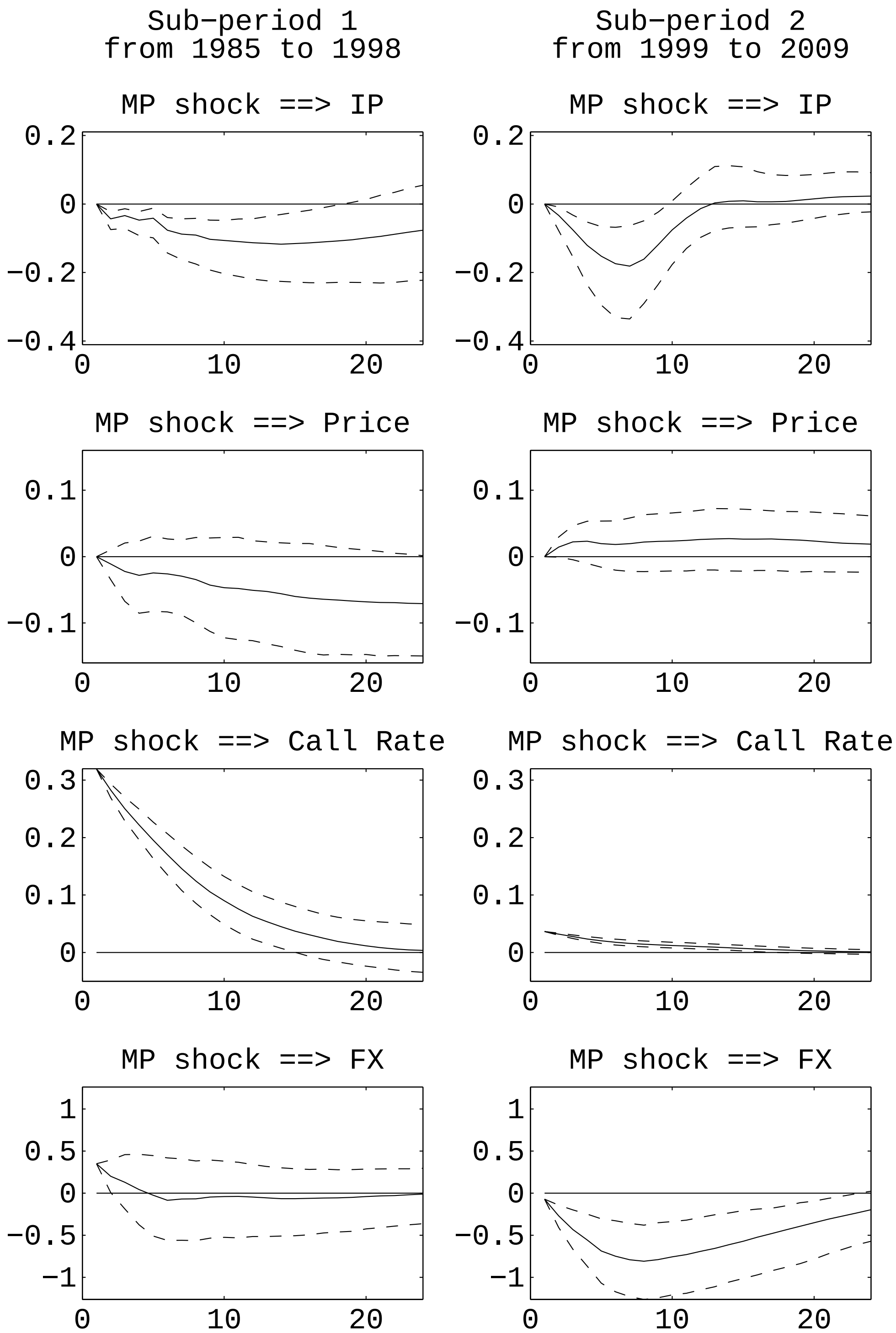

Figure 3: Responses of interest rates to monetary policy shocks in the model without exogenous variables. The left panel covers the pre-ZIRP period and the right one covers the ZIRP period from 1996 to 2009.

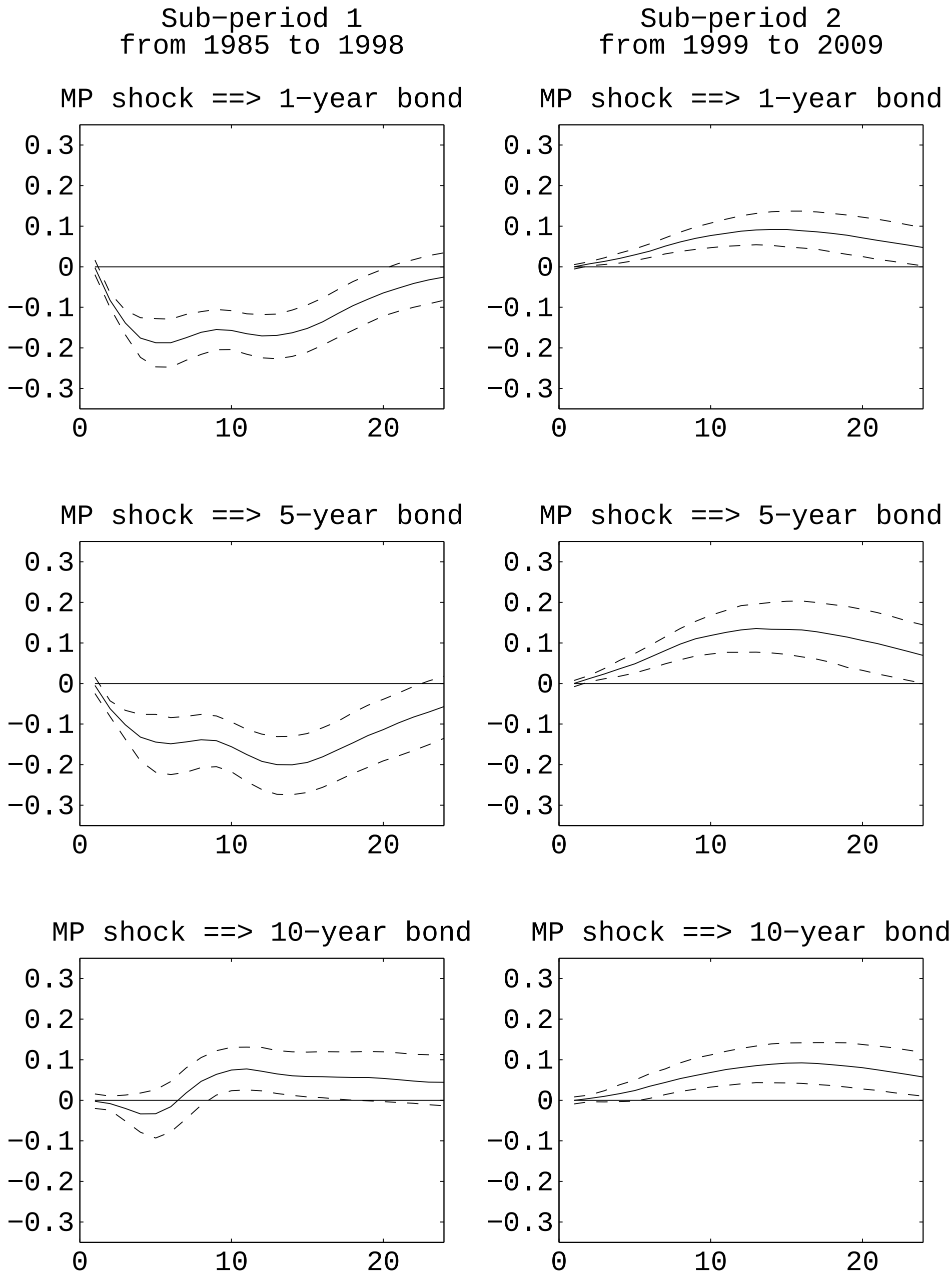

Figure 4: Responses of macroeconomic variables to monetary policy shocks in the model without exogenous variables. The left panel covers the pre-ZIRP period and the right one covers the ZIRP period from 1996 to 2009.