

# Economic Fluctuation and Japanese Monetary Policy: Two Empirical Studies with SVAR Approach

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## Abstract

The paper investigates the effects of Japanese monetary policy with two structure VAR (SVAR) analyses. Firstly, it constructs SVAR model using seven economic variables of Japan and assumes a particular structure matrix to identify it. By estimating this model with monthly data from 1970:01 to 2002:12, it shows the following main results, 1) interest rate shock and money supply shock have significant effects on economic variables; 2) the shock's effect of the credit from central bank is very small; 3) the effect of exchange rate shock is limited 4) the Bank of Japan implements monetary policy by both of interest rate and money supply. Secondly, following Huang and Guo (2006) and NG (2002), it introduces the world GDP to denote world economy growth and oil price to denote world price level, and estimates SVAR model containing them and Japanese interest rate and exchange rate. Empirical results show that the external demand shock has negative effect on exchange rate and positive effect on interest rate, and the external supply shock has positive effects on both exchange rate and interest rate.

Keyword: SVAR, Monetary policy, World GDP.

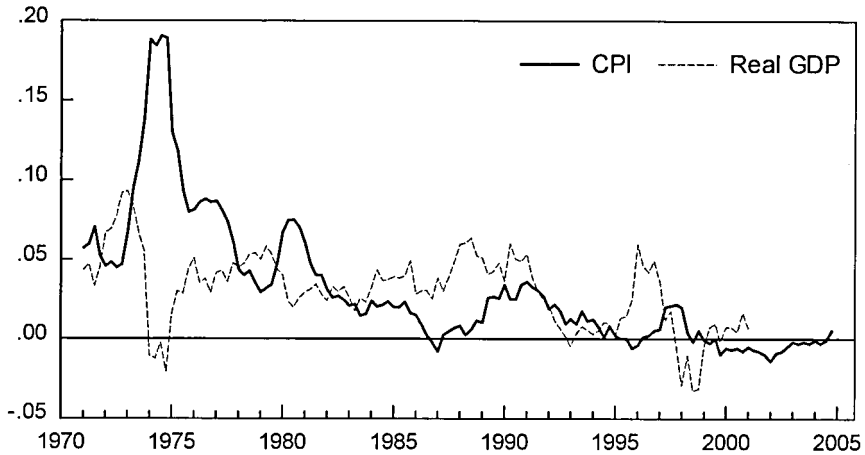
## 1 Introduction

Since 1970s, the Bank of Japan began to reform its outdated rules and regulations, in order to change the financial market of Japan, which was relatively insulated from international capital markets in the past, into a completely liberal and international financial market. In the same period, Japanese economy also experienced a series of important events. In 1970s, two oil crises occurred in October 1973 and December 1978 badly shocked Japanese and world economy. In 1980s, according “Plaza Accord (September 1985)” and “Louvre Accord (February 1987)”, the Bank of Japan began to intervene international financial markets to stabilize the exchange rate of Japan's national currency. In 1990, the “bubble economy” depending on low interest rate and high growth rate of money supply burst, then Japanese economy fell into deep recession, called “Heisei Recession”. In order to cure the recession, the Bank of Japan continued to lower the interest rate, which was raised in 1989, until it touched on its historical low level, 0.5 percent in September 1995. But these loose monetary policies didn't help the macroeconomic indicators come back to

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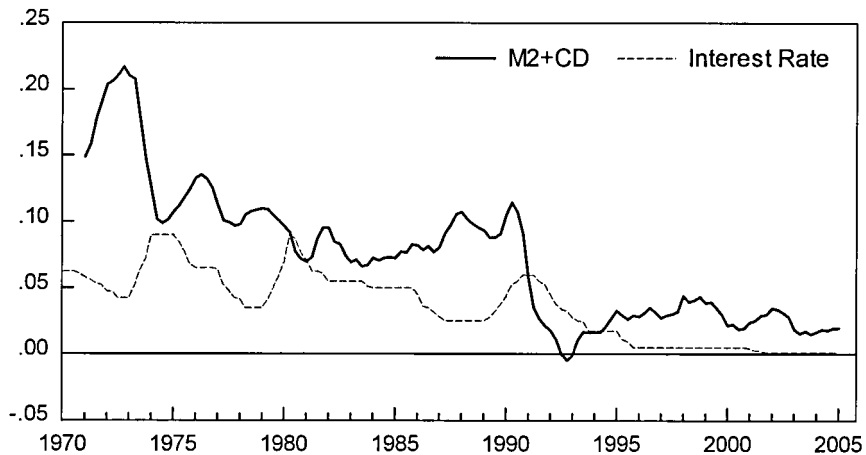
previous level. Moreover the deflationary pressure existed still. Since February 1999, the Bank of Japan decreased the official discount rate to 0.01 percent and instituted the “Zero Interest Rate Policy” by providing reserves at near zero call rate, thus short-term interest rates have mostly remained near zero. Also, in March 2001, the Bank of Japan instituted the “Quantitative Easing Policy,” the current account balances at the Bank of Japan grew dramatically from ¥4 trillion to more than ¥30 trillion in 2004. Figures 1 and 2 show the growth rates of CPI and real GDP, the interest rate and the growth rate of M2+CD since 1970s.

Figure 1 Growth rate of CPI and real GDP in Japan



Note: Growth rates are calculated against the same quarter in the previous year.  
Source: NEEDS.

Figure 2 Interest rate and growth rate of M2+CD in Japan



Note: Growth rates is calculated against the same quarter in the previous year.  
Source: NEEDS.

The brief overview above shows that since 1970 in order to achieve the aims of price stability and development of national economy<sup>2)</sup>, the Bank of Japan had implemented various monetary policies, even the unprecedented loose policy, to respond to the changes of Japanese economy and world economy. Did these

monetary policies properly react to the changes of Japanese and world economy? Were these monetary policies helpful for achieving the aims of the Bank of Japan? How to measure the effects of monetary policies? About these questions, economists have made a lot of studies on both of theory and empirical analysis, and proposed various views in the early literature<sup>②</sup>.

This paper focuses on two empirical analyses by employing SVAR theory, and tries to find some new and helpful evidence to completely measure the effects of monetary policy in Japan since 1970s.

Firstly, it estimates and studies an SVAR model using Japan's data. Comparing with the similar works made by other researchers, for instance, Iwabuti (1990), Kasa and Popper (1997), Mihira and Sugihara (2000), Terayame (2001), Shioji (2002), Miyao (2000, 2002, 2003, 2006) and Nakashima (2004a, 2004b). This study is different from these works with three characteristics. First, it assumes a particular structure matrix to identify SVAR model and uses it to design four hypotheses about monetary policy instrument of the Bank of Japan. Second, it introduces more economic variables into the model, not only industrial production, consumer prices, exchange rate, the call rate, broader money supply M2+CD but also Nikkei 225 average index and the credit from monetary authorities. By studying this system, it tries to answer what roles are played by interest rate, money supply, and the credit from monetary authorities in Japanese economy and how does exchange rate affect other economic variables. Finally, in order to study the characteristics of monetary policy in different periods, the models are estimated with full sample period (1970:01-2002:12) and three sub-sample periods: 1970:01-1985:12, 1980:01-1995:12, and 1995:01-2002:12.

Secondly, it studies the relationship between the world economy and Japanese monetary policy. Following Huang and Guo (2006) and NG (2002), this study uses the world GDP index to denote the world economy growth and oil price to denote the world price level. By estimating this SVAR containing above two variables, it tries to explain how does the change of world economy affect Japanese monetary policy, or how does the Bank of Japan implement its monetary policy to respond the change of the world economy.

This paper is organized as follows. Section 2 briefly summarizes VAR theory. Section 3 reviews some early literature about measuring the effects of monetary policy in Japan by VAR approach. Section 4 studies the effects of monetary policy using Japanese economic variables. Section 5 studies the relationship between the external shocks and Japanese monetary policy. The last section summarizes the conclusion.

## 2 Vector Autoregressive (VAR) Model

Vector autoregression (VAR) model is primarily applied to macroeconomic analysis by Sims (1980), and developed by many economists afterward<sup>③</sup>. In the past two decades, VAR model and structure vector autoregressive (SVAR) model are frequently used to measure the effects of monetary policy of the central bank. This procedure provides a framework for studying the multivariable time series model. As a

<sup>②</sup> See "The Bank of Japan Law," Article 2.

<sup>③</sup> See Ito (1989), Hetzel (1999, 2004), etc.

<sup>④</sup> See, Blanchard and Quah (1989), Sims (1992), Bermanke and Blinder (1992), Bermanke and Mihov (1998), and Christiano, Eichenbaum and Evans (2000).

convenient statistical representation of the relationships among the variables, VAR model can be simply used to study the dynamic of macroeconomic variables in a system. For example, calculating the impulse response function can help one to draw the dynamic reaction of a variable to the shock of other variables, and the forecast variance decomposition can be used to obtain the contributions of shocks in the forecast variance of interesting variable.

The general form of VAR model is represented as,

$$B_0 Y_t = c + B_1 Y_{t-1} + B_2 Y_{t-2} + \dots + B_q Y_{t-q} + \varepsilon_t \quad (1)$$

$Y_t$  is a  $k$ -dimensional vector containing economic variables, its element  $\{y_{it}\}$  ( $i = 1, 2, \dots, k$ ) is stationary and affected by past realizations of each sequence and the current values of all other variables in  $Y_t$  ( $B_0$  is a parameter matrix with one on its diagonal).  $c$  is the intercept vector,  $q$  is a nonnegative integer representing lag length and  $B_l$  ( $l = 1, \dots, q$ ) is  $k \times k$  parameter matrix.  $\varepsilon_t$  is assumed as a normally distributed white noise disturbance vector with  $\varepsilon_{it} \sim N(0, \sigma_i^2)$ ,  $i = 1, \dots, k$ ,  $E(\varepsilon_t) = [0]$ ,  $E(\varepsilon_t \varepsilon_t') = D$  and  $E(\varepsilon_t \varepsilon_s') = [0]$  ( $t \neq s$ ).

Equation (1) is a structural VAR but not a set of reduced-form equations because  $y_{it}$  contains contemporaneous effect of other variables. By left-multiplying it by  $B_0^{-1}$ , it can be transformed to standard-form (or reduced-form) VAR:

$$Y_t = C + A_1 Y_{t-1} + A_2 Y_{t-2} + \dots + A_q Y_{t-q} + e_t \quad (2)$$

$$E(e_t, e_t') = B_0^{-1} D (B_0^{-1})' = V \quad (3)$$

where  $C = B_0^{-1} c$ ,  $A_l = B_0^{-1} B_l$ , ( $l = 1, \dots, q$ ),  $e_t = B_0^{-1} \varepsilon_t$ . Introducing a matrix polynomial about lag operator  $L$ ,  $A(L) = I - A_1 L - \dots - A_q L^q$ , the compact form of Equation (2) can be obtained as:

$$A(L) Y_t = C + e_t \quad (4)$$

The standard-form VAR, can be estimated by using OLS without any prior constraint, but the SVAR can not. Each off-diagonal element in  $V$  indicates the covariance of  $\{e_t\}$ . Because  $\text{cov}(e_t, e_s) = \text{cov}(e_s, e_t)$  for  $t \neq s$ ,  $V$  is a symmetric matrix which contains at most  $k(k+1)/2$  known elements yielded from estimating standard VAR. Thus Equation(3) provides  $k(k+1)/2$  equations. However, recalling that  $\varepsilon_{it}$  is white noise series so  $D$  contains  $k$  unknown parameters on its diagonal matrix. In addition,  $B_0^{-1}$  contains  $k^2 - k$  unknown parameters. Thus the number of all unknown parameters is  $k^2$ . Clearly, it is not possible to determine these unknown parameters unless  $k(k-1)/2$  restrictions are imported.

## 2.1 Identification of SVAR Model

As discussed above, SVAR can not be directly estimated if no restriction is imported. So how to identify an assumed SVAR model is usually mentioned in most literature. The existent identifying restrictions usually used to study monetary policy can be summarized as: Cholesky decomposition, block recursive

restriction, short-run restrictions, long-run restrictions and Bernanke-Mihov approach. The key point of the first three is that restrictions are imported to eliminate a part of the contemporaneous effects of variables. In the long-run restriction, the long-run effects of variables are considered as the restriction conditions. In the last one, only the relations among observable and unobservable structure shocks which can affect monetary policy are considered as the restriction conditions.

Cholesky decomposition is the simplest and most convenient way. It was frequently employed in literature, for example, Sims (1992), Miyao (2000, 2002). By restricting matrix  $B_0$  as a lower triangular and the elements on its diagonal as one, the number of unknown parameters is reduced  $k(k-1)/2$ .

The block recursive restriction is introduced by Christiano, Eichenbaum, and Evans (1999). It supposes that policy maker observes the information set  $\Omega_t$  when policy is set at  $t$  period. If some economic variable's contemporaneous values appear in  $\Omega_t$ , and others only appear with a lag in  $\Omega_t$ ,  $Y_t$  can be partitioned into three blocks:

$$Y_t = \begin{bmatrix} X_{1t} & S_t & X_{2t} \end{bmatrix}' \cdot \quad (5)$$

$\begin{matrix} k_1 \times 1 & 1 \times 1 & k_2 \times 1 \end{matrix}$

where  $k = k_1 + 1 + k_2$ , the element in  $X_{1t}$  is the predetermined variable and their contemporaneous values appear in  $\Omega_t$  (they are not effected by the realizations of  $S_t$  and  $X_{2t}$ ).  $S_t$  is the policy variable and its shock is orthogonal to the elements in  $X_{1t}$ . The element in  $X_{2t}$  is a variable effected by the current values of  $X_{1t}$  and  $S_t$ , but it has no contemporaneous effect on  $X_{1t}$  and  $S_t$ . Then, the coefficient matrix  $B_0$  is restricted as follows,

$$B_0 = \begin{bmatrix} B_{11} & 0 & 0 \\ B_{21} & B_{22} & 0 \\ B_{31} & B_{32} & B_{33} \end{bmatrix} \cdot \quad (6)$$

$\begin{matrix} k_1 \times k_1 & k_1 \times 1 & k_1 \times k_2 \\ 1 \times k_1 & 1 \times 1 & 1 \times k_2 \\ k_2 \times k_1 & k_2 \times 1 & k_2 \times k_2 \end{matrix}$

Christiano, Eichenbaum and Evans (1999) proved that it permits to restrict blocks  $B_{11}$  and  $B_{33}$  as lower triangular matrix by setting zero restrictions individually to yield the response function of real economic variable to monetary policy shock.

The short-run restriction is similar to above procedure. It introduces at least  $k(k-1)/2$  restrictions into matrix  $B_0$  to identify SVAR model. Significantly, the difference is that it is not necessary to set all of restrictions to zero or to restrict matrix  $B_0$  as a triangular. In other words, it allows the existence of contemporaneous effects. For example, Blanchard and Watson (1986) estimated an AD-AS (aggregate demand-aggregate supply) form SVAR model using short-run restrictions as follows:

$$\begin{bmatrix} 1 & a_{yp} & -a_{yg} & -a_{ym} \\ -a_{py} & 1 & 0 & 0 \\ -a_{gy} & -a_{gp} & 1 & 0 \\ -a_{my} & -a_{mp} & 0 & 1 \end{bmatrix} \begin{bmatrix} y_t \\ p_t \\ g_t \\ m_t \end{bmatrix} = A(L) \begin{bmatrix} y_t \\ p_t \\ g_t \\ m_t \end{bmatrix} + \varepsilon_t$$

aggregate demand equation  
 aggregate supply equation  
 financial policy equation  
 monetary policy equation

where  $y, p, g$  and  $m$  indicate income, price, government expenditure and money supply, respectively. They assume that: (a) aggregate demand is negative correlated with price, positive correlated with government

expenditure or money supply; (b) aggregate supply has a positive association with price; (c) financial policy and monetary policy is set to stabilize income and price. Since the number of restrictions equals to  $k(k-1)/2 = 4(4-1)/2 = 6$  and the number of zero restrictions equals to 4, it needs two more restrictions. Blanchard and Watson (1986) set  $a_{yp}, a_{gp}$  as appropriate parameters by considering the responses to financial policy<sup>9</sup>.

The long-run restriction is proposed by Blanchard and Quah (1989). The key points of this procedure are that: (a) decompose real aggregate variable into two components, temporary and permanent; (b) consider that demand-side shocks have not long-run effects on real aggregate variable. From Equation (13), which will be explained later, the long-run cumulative impulse responses of  $Y_t$  to structural shock  $\varepsilon_{jt}$  is

$$\sum_{s=0}^{\infty} \gamma_{s,ij} = \sum_{s=0}^{\infty} [\Omega_s]_{i,j} d\varepsilon_{jt} = \left[ \sum_{s=0}^{\infty} \Omega_s \right]_{i,j} d\varepsilon_{jt} . \quad (7)$$

By considering long-run impartiality of some economic variables, one can use zero restrictions in the above matrix to indicate the change of one variable without long-run effect on some others.

The last identify procedure is proposed by Bernanke and Mihov (1995). They separate the variables into two parts, non-policy macroeconomic variables and policy variables, and impose a “semi-structural” VAR to measure the stance of monetary policy in the United States. They assume that policy shock has no contemporaneous effect on the macroeconomic variables. Under this assumption, they argue that it is not necessary to identify the entire model to study the dynamic effects of exogenous policy shocks on macroeconomic variables, and it is sufficient to identify the equations about policy variables. This procedure is also employed by Kasa and Popper (1996) and Nakashima (2004b) to study Japanese data.

## 2.2 Impulse Response Function:

The standard-form VAR can be rewritten into vector moving average (VMA) description as,

$$Y_t = A(L)^{-1} C + A(L)^{-1} e_t = \tilde{C} + (I - A_1L - \dots - A_qL^q)^{-1} e_t \quad (8)$$

where  $\tilde{C}$  represents the estimations of  $Y_t$ . It isn't difficult to find an expression  $\phi(L) = I + \phi_1L + \phi_2L^2 + \dots = (I - A_1L - \dots - A_qL^q)$  to satisfy the following condition:

$$(I - A_1L - \dots - A_qL^q)(I + \phi_1L + \phi_2L^2 + \dots) = I,$$

then  $Y_t = \tilde{C} + (I + \phi_1L + \phi_2L^2 + \dots)e_t$ .

Define  $\phi_{s,ij}$ , called impact multiplier, to represent the element on the i-th row and the j-th column of  $\phi_s$ , the i-th equation of the system can be represented as,

$$y_{it} = \tilde{C}_i + \sum_{j=1}^k (\phi_{0,ij} e_{jt} + \phi_{1,ij} e_{j,t-1} + \phi_{2,ij} e_{j,t-2} + \dots). \quad (9)$$

The right side of the above expression provides a procedure to measure the cumulative effect on the i-th

<sup>9</sup> See Blanchard and Watson (1986) for the details.

variable of the reduced shocks in  $e_j$ , which occurred at all past time period before  $t$  period. For example,  $\phi_{0,ij}$  represents the instantaneous effect of unit-change in  $e_j$  on  $y_{it}$ ,  $\phi_{1,ij}$  is the effect of unit-change in  $e_j$  occurred at one period ahead on  $y_{it}$ . Then, the cumulative effect of this change after  $n$  periods is,

$$\sum_{s=0}^n (\phi_{s,ij}). \quad (10)$$

If using differential notation to display the impulse response function, the compact form of the impact multiplier is given as

$$\phi_{s,ij} (= dY_{i,t+s}) = \frac{\partial y_{i,t+s}}{\partial e_{jt}} de_{jt} = [\phi_s]_{i,j} de_{jt}. \quad (11)$$

If  $B_0^{-1}$  is known, it is easy to transform standard-form shocks into structural shocks to yield the impulse response function of SVAR as follows,

$$\begin{aligned} Y_t &= A(L)^{-1} B_0^{-1} c + A(L)^{-1} B_0^{-1} \varepsilon_t \\ &= \tilde{C} + \phi_0 B_0^{-1} \varepsilon_t + \phi_1 B_0^{-1} \varepsilon_{t-1} + \phi_2 B_0^{-1} \varepsilon_{t-2} + \dots \\ &= \tilde{C} + \Omega_0 \varepsilon_t + \Omega_1 \varepsilon_{t-1} + \Omega_2 \varepsilon_{t-2} + \dots \end{aligned} \quad (12)$$

$$\gamma_{s,ij} (= dY_{i,t+s}) = \frac{\partial y_{i,t+s}}{\partial \varepsilon_{jt}} d\varepsilon_{jt} = [\Omega_s]_{i,j} d\varepsilon_{jt}. \quad (13)$$

Plotting all values of expression for will obtain a graph exhibiting the accumulative reaction of  $i$ -th variable to a shock in  $j$ -th variable.

### 2.3 Forecasting Error Variance Decomposition:

The impulse response functions can be used to describe how variables react to a shock of endogenous variable in VAR. But as a procedure for studying the effect relations among the variables, it would be too fine. Sims (1980) proposed a procedure called variance decomposition to treat the effect relations. By decomposing the changes in an endogenous variable into the component shocks to the VAR, it describes the information about the relative importance of each random innovation.

From Equation (9), the variance of the cumulative effect is calculated by:

$$E[(\phi_{0,y} e_t + \phi_{1,y} e_{t-1} + \phi_{2,y} e_{t-2} + \dots)^2] = \sum_{p=0}^{\infty} (\phi_{p,y}^2) \sigma_{y_j}^2. \quad (14)$$

Thus, the variance of  $y_{it}$  is obtained as:

$$\text{var}(y_{it}) = \sum_{j=1}^k \left[ \sum_{p=0}^{\infty} (\phi_{p,y_j}^2) \sigma_{y_j}^2 \right]. \quad (15)$$

Denote  $RVC_{j \rightarrow i}(\infty)$  (Relative variance contribution) to measure the contribution of the shock in  $\varepsilon_{jt}$  on  $y_{it}$ :

$$RVC_{j \rightarrow i}(\infty) = \frac{\sum_{p=0}^{\infty} (\phi_{p,ij}^2) \sigma_{ij}^2}{\text{var}(y_{ij})} = \frac{\sum_{p=0}^{\infty} (\phi_{p,ij}^2) \sigma_{ij}^2}{\sum_{j=1}^k \sum_{p=0}^{\infty} (\phi_{p,ij}^2) \sigma_{ij}^2} \quad (16)$$

Actually, it is not possible to study the effect of a shock from negative infinity period. If one is interested in shocks from  $s$  period ahead, the RVC is

$$RVC_{j \rightarrow i}(s) = \frac{\sum_{p=0}^{s-1} (\phi_{p,ij}^2) \sigma_{ij}^2}{\sum_{j=1}^k \sum_{p=0}^{s-1} (\phi_{p,ij}^2) \sigma_{ij}^2} \quad (17)$$

The larger the value of RVC is, the more significant the effects of the  $j$  th variable on the  $i$  th variable will be.

### 3 Literature Review

#### 3.1 Kasa and Popper (1996)

This paper studies the objectives and operating procedures of the Bank of Japan during the period from 1975 to 1994, by estimating SVAR model using Bernanke and Mihov approach. As they described, in the 1970s, the Bank of Japan conducted monetary policy largely by controlling discount windows borrowing in two main ways, "moral suasion" and "windows guidance". The former is used to control bank's borrowing at the discount windows, while the latter is used to restrict bank lending. The Bank of Japan began to use open market operations in 1981, then introduced a financial liberalization package in the mid-1980s, finally deregulated the interbank market in 1988.

In their SVAR model, the vector of non-policy variables includes commodity price index, consumer price index, index of industrial production, and the exchange rate. While the vector of policy variable includes the call money rate, total reserves, non-borrowed reserves, and a measure of moral suasion. They used the difference between the three-month CD rate and the two-month "Tegata" rate to measure the extent of moral suasion. In the policy equations, the relationship between the observable residuals  $u^p$  and the unobservable random disturbances  $v^p$  is set as:

$$\begin{cases} u^r &= -\alpha u^m + v^d \\ u^{br} &= \beta u^m - \delta u^{ms} + v^b \\ u^{nbr} &= \phi^d v^d + \phi^b v^b + \phi^m v^m + v^s \\ u^{ms} &= \gamma^b v^b + \gamma^s v^s + v^m \end{cases}$$

The demand for total reserves described by the first equation negatively depends on the change in the call money rate with strength  $\alpha$ , and depends on demand disturbance for total reserves. The demand for



borrowed reserves described by the second equation can be explained similarly. The third and fourth equation describe monetary policy and the use of moral suasion, respectively. By this SVAR, they test five hypotheses about the conduct of monetary policy:

- 1) Non-borrowed reserves targeting  $\phi^m = 0, r^s = 0$  ;
- 2) Call money rate targeting  $\phi^d = 1, \phi^b = \delta r^b - 1$  ;
- 3) Total reserves targeting  $\phi^d = -(\beta / \alpha), \phi^b = \delta r^b - 1$  ;
- 4) Borrowed reserves targeting  $\phi^d = 1, \phi^b = (\alpha / \beta)(1 - \delta r^b)$  ;
- 5) Weighted non-borrowed reserves/call money targeting

$$\phi^d = [1 + \omega(\alpha + \beta)]^{-1}, \phi^b = (1 - \delta r^b) / [1 + \omega(\alpha + \beta)].$$

where  $\omega$  is the estimated ratio of the weight on non-borrowed reserves and the weight on the call money rate.

The results of test show that the hypotheses 2, 3, and 4 are rejected and the last hypothesis is much better than any single hypothesis. Thus, they argue that: "...no single target can explain the Bank of Japan's behavior. Instead, the Bank of Japan appears to weight both variation in non-borrowed reserves and variation in the call money rate increasing over time...."

However, because of the problems on the use of the non-borrowed reserves variable, it invited some criticisms, for example Shioji (2000) and Miyao (2002).

### 3.2 Etsuro Shioji (2000)

In order to answer whether a specific component or total amount of high-powered money is controlled by Japanese central bank to influence the private economy in the short run, Shioji (2000) constructs two models. One called H model is based on the standard view that the central bank controls the total amount of high-powered money; the other called BL model is based on alternative view that the central bank controls its loans. The results of analysis show that the former yields much more sensible estimates than the latter.

The SVAR constructed in this paper contains eight variables: P-S-O-Y-R-M-H-BL. They denote consumer price index, living expenditure of all households, new orders for machinery, industrial production, short-term interest rate, money stock (M2+CD), high-powered money and the Bank of Japan loans outstanding, respectively. These variables are divided into two sectors: non-financial sector (P, S, O and Y) and financial sector (R, M, H and BL). The financial sector consists of four equations: the central bank (CB), the M demand (MD), the H demand (HD), and the BL demand (BLD) equations. The identifying restrictions are given as

$$\begin{pmatrix} u_P \\ u_S \\ u_O \\ u_Y \\ u_R \\ u_M \\ u_H \\ u_{BL} \end{pmatrix} = \begin{pmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ a_{2P} & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ a_{3P} & a_{3S} & 0 & 0 & 0 & 0 & 0 & 0 \\ a_{4P} & a_{4S} & a_{4O} & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & a_{5M} & a_{5H} & a_{5BL} \\ a_{6P} & a_{6S} & a_{6O} & a_{6Y} & a_{6R} & 0 & 0 & 0 \\ a_{7P} & a_{7S} & a_{7O} & a_{7Y} & a_{7R} & a_{7M} & 0 & 0 \\ a_{8P} & a_{8S} & a_{8O} & a_{8Y} & a_{8R} & a_{8M} & a_{8H} & 0 \end{pmatrix} \begin{pmatrix} u_P \\ u_S \\ u_O \\ u_Y \\ u_R \\ u_M \\ u_H \\ u_{BL} \end{pmatrix} + \begin{pmatrix} e_P \\ e_S \\ e_O \\ e_Y \\ e_{CB} \\ e_{MD} \\ e_{HD} \\ e_{BLD} \end{pmatrix}.$$

$u$ 's are residuals from the first stage OLS estimation and  $e$ 's are structural shocks. The H model is constructed by excluding BL from the central bank equation ( $a_{5BL} = 0$ ). In the BL model, H is excluded from the central bank equation ( $a_{5H} = 0$ ).

The results of impulse response analysis and variance decomposition analysis support author's view. The impulse response analysis for a "tight money shock" (an increase in  $e_{CB}$ ) show that: (1) in the H model, there is not the "liquidity puzzle" <sup>Ⓒ</sup>, in the BL model, the response curve of BL strongly goes down initially; (2) in the H model, there is not the "price puzzle" <sup>Ⓒ</sup>, in the BL model, P goes up significantly initially for nearly a year; (3) the responses of S, O, and Y are negative and significant in H model, but not in BL model. While, variance decomposition analysis for H model shows that, (1) policy shock and demand shock have important effects on R and monetary aggregates within one month; (2) policy shocks have larger effect on P, S, O, Y in the long run; (3) policy shocks have long-lasting large effects M and H.

Finally, the author compares his results with some papers about U.S. data. The same conclusion is that response of price level to a policy shock changes slowly. Two different points are that, the author suggests that monetary policy shocks have relatively large effect on output (over 40%) and contribute to more than half of the change in M and H, while most studies about U.S. data are smaller.

### 3.3 Miyao Ryuzo (2000)

Miyao (2000) studies the effects of Japan's monetary policy by estimating the sample of 1975-1998 based on the VAR methodology, and argues that: "(1) monetary policy has a persistent effect on real output over the full sample and the sub-sample that ends in 1993, such effect disappears with the recent sub-sample of the 1990s; (2) there is a break in the reduced form dynamic system in 1995."

By considering that shocks to short-term interest rates are the indicator of exogenous monetary policy, the author builds two VAR models. One is a three-variable model containing the call rate ( $r$ ), industrial production ( $y$ ), and the money base ( $m$ ). The other one is a four-variable model which contains ( $r$ ), ( $y$ ), ( $m$ ), and nominal effective exchange rate ( $e$ ). The optimal lag length is set to ten based on SBIC and the models are identified by Cholesky decomposition.

The author estimates the impulse responses for all variables in lever up to 120 months, and computes one standard error bond by a Monte Carlo integration procedure with 500 replications. The results of estimating three-variable model show that: a) A rise in the call rate  $\epsilon_r$  causes negatively persistent effects on both of real output and monetary base; b) A real disturbance  $\epsilon_y$  has positive effects on the call rate and output; c) A rise in the monetary base  $\epsilon_m$  has positive effects on the real output or on the call rate. The main results of four-variable model are similar to the above. In addition, a rise in the exchange rate has positive effect on the real output and negative effect on the call rate.

In order to examine the possible structural shift in model, the author also estimates real output responses in two sub-sample: 1975:1-1993:12 and 1990:9-1998:4, and compares two results with the results of the full

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<sup>Ⓒ</sup> It often appears in VAR analysis about US monetary policy. That is, in response to an identified monetary policy, M (or H or total reserves) and R move in the same direction, but not opposite.

<sup>Ⓒ</sup> It is similar to the "liquidity puzzle" that after a contractionary monetary policy, the price level increases but not decreases.

sample: in the former sub-sample,  $\epsilon_r$ , and  $\epsilon_y$  shocks have similar effects on real output with the full sample; while in the latter sub-sample, only  $\epsilon_y$  and  $\epsilon_m$  shock have similar effect on real output with the full sample, but  $\epsilon_r$  shock has a very limited effect on real output, and  $\epsilon_e$  shock has a limited, slightly negative effect on real output. Based on these facts, author argues that there is a significant break in the role of monetary policy in sometime during the 1990s. The results of structural stability test find that, three-variable model rejects the null hypothesis of no structural shift against the alternative of a structural shift in 1995 and 1996, and four-variable model rejects the null only in 1995. These indicate that if the parameter values ever shifted, it is most likely in 1995.

At the end of paper, it mentions that by incorporating the price level  $p$  into the models, the real output responses in four- and five-variable models ( $(r, p, y, m)$ ,  $(r, p, y, m, e)$ ) are similar to those obtained before.

### 3.4 Miyao Ryuzo (2002)

In this paper, the author imports the stock prices, as a measure of asset prices in Japan, into VAR model. The main results are that “monetary shocks in fact have a persistent effect on real output especially in the rise and fall of Japan's 'bubble economy' in the late 1980s.”

The paper first describes the institutional features of operating procedures of the Bank of Japan, and argues that “the call market rate, not monetary aggregate, is arguably the best monetary policy measure in Japan, and the interest rate is predetermined for monetary aggregates.” Then it forms a VAR model by employing four variables: the call rate ( $r$ ), the monetary base ( $m$ ), stock price ( $p_t$ ), and industrial production ( $y$ ). By using the similar procedure to Miyao (2000), it obtains the results of impulse responses analysis as follows: (1) A call rate shock (contractionary monetary policy) has a negatively persistent effect on real output, a negative effect on stock prices, and a negative effect on monetary base; (2) A monetary shock has positive effects on the call rate, stock prices, and the real output; (3) Stock price shock has a long-lasting effect on real output and plausible positive effects on the call rate and the base money; and (4) A real output shock slightly raises the stock price. This paper also describes four historical decompositions of real output, and indicates that the structural disturbances have close relationship with real output.

Finally, by examining several alternative frameworks using different ordering (four-variable) and comparing the long-run responses of output, it finds that, in all case, a call rate shock has a significant effect on real output (-0.81 to -0.85), and the benchmark results seem to be fairly robust. The results of impulse responses and the historical decomposition also exhibit the similar results.

### 3.5 Miyao Ryuzo (2003)

Since the Bank of Japan lowered its discount rate to 0.5% in 1995, it seems that more attentions are paid to Japanese central bank's policy about foreign exchange intervention. To test whether depreciation of Yen has strong effect on Japan economy, Miyao (2003) estimates three VARs containing exchange rate, and argues that depreciation of Yen has not so strong effect as expected.

Three VARs are constructed by  $(EX, IM, e)$ ,  $(EX, r, IM, e)$ , and  $(EX, y, IM, e)$ . The symbols  $EX, IM, y, r$ , and  $e$  denote export, import, real GDP, the call rate and exchange rate, respectively. The identifying condition is set as a standard short-run recursive type. The export is set as the first exogenous variable and the exchange rate is set as the first endogenous variable. The results of all three VARs show that exchange rate shocks have significant negative effects on import, and have smaller positive effects on export initially but negative effects in the long-run. The latter two models show that exchange rate shocks have positive effect on the call rate and negative effect on real GDP. The strength of both two effects are not large.

It is similar to his former papers, author tests a series of alternative models constructed by changing the ordering of variables and a VAR containing five variables  $(EX, r, y, IM, e)$ . There is no variety in the main results about the effect of exchange rate.

## 4 Economic Fluctuation and Monetary Policy in Japan

### 4.1 Description of Model

The SVAR is set as

$$A_0 Z_t = c + A(L) Z_{t-1} + \varepsilon_t, \quad (18)$$

where  $c$  is the intercept vector,  $A(L) = A_1 L + A_2 L^2 + \dots + A_p L^p$  is matrix polynomial about lag operator  $L$ ,  $p$  is lag length (nonnegative integer) and  $A_i (i=1, \dots, p)$  are  $k \times k$  parameter matrices.  $Z_t$  is divided into three blocks:

$$Z_t = (X_{1t}, S_t, X_{2t})', \quad (19)$$

$X_{1t} (k_1 \times 1)$  describes the non-policy variables,  $S_t (1 \times 1)$  describes the policy target and its shock is orthogonal to the elements in  $X_{1t}$ , and  $X_{2t} (k_2 \times 1)$  describes the policy instrument variables. The number of all variables is  $k = k_1 + 1 + k_2$ .  $\varepsilon_t$  is assumed as a normally distributed white noise disturbance vector with  $\varepsilon_{it} \sim N(0, \sigma_i^2)$ ,  $i=1, \dots, k$ ,  $E(\varepsilon_t) = [0]$ ,  $E(\varepsilon_t \varepsilon_s') = D$  and  $E(\varepsilon_t \varepsilon_s') = [0]$  ( $t \neq s$ ). Following Christiano, Eichenbaum and Evans (1999), the recursive assumption for identifying the SVAR is given as

$$A_0 = \begin{bmatrix} A_{0,11} & A_{0,12} & A_{0,13} \\ k_1 \times k_1 & k_1 \times 1 & k_1 \times k_2 \\ A_{0,21} & A_{0,22} & A_{0,23} \\ 1 \times k_1 & 1 \times 1 & 1 \times k_2 \\ A_{0,31} & A_{0,32} & A_{0,33} \\ k_2 \times k_1 & k_2 \times 1 & k_2 \times k_2 \end{bmatrix} \quad (20)$$

By modifying the procedures used by Iwabuchi (1990), Christiano, Eichenbaum, and Evans (1999), and Shioji (2000), the following macroeconomic variables are chosen to characterize Japanese economy and monetary policy. Non-policy variables include industrial production ( $IP$ ), consumer price ( $CP$ ), exchange

rate (*EX*), Nikkei 225 average index (*NK*). Industrial production can be used to measure the real economic growth. Consumer price is treated as inflation indicator. The reason for inclusion of exchange rate is that the Bank of Japan began intervening foreign exchange market from 1980s. It means that the Bank of Japan tries to affect exchange rate by its monetary policy. Moreover, as shown in Table 1, all of the correlation coefficients between exchange rate and other variable are larger than 0.6, especially, the coefficients about *IP*, *CP*, and *M2* are larger than 0.9 or less than -0.9. *NK* is used to approximately represent the variety in asset price<sup>®</sup>. The call rate (*R*) is policy target variable. Policy instrument variables include broader money supply *M2+CD* (*M2*) and the credit from monetary authorities (*CR*). The latter comprises banking institution's (commercial banks and other financial institutions) borrowing from the central bank. As described in Kasa and Popper (1996), the Bank of Japan conducted monetary policy largely by controlling discount windows borrowing in 1970s, so its effect is also interested here. Thus, the ordering of variables is (*IP*, *CP*, *EX*, *NK*, *R*, *M2*, *CR*)<sup>®</sup>.

For identifying the system, the assumptions for coefficients matrix  $A_0$  are set as: 1)  $A_{0,11}$  and  $A_{0,33}$  are lower triangular matrices (according to the results proved by Christiano, Eichenbaum, and Evans [1999]); 2) Both of policy target variable and policy instrument variables have no contemporaneous effect on all non-policy variables ( $A_{0,12}=A_{0,13}=[0]$ ); 3) Monetary policy maker sets the policy target and the policy instrument by seeing the current observations of non-policy variables ( $A_{0,21}=A_{0,31}\neq[0]$ ); 4) Policy target variable has contemporaneous effect on policy instrument variables ( $A_{0,32}\neq[0]$ ). Hence,  $A_0$  is reified as,

Table 1 The correlations of variables

	CP	CR	EX	IP	M2	NK	R
CP	1.00						
CR	0.58	1.00					
EX	-0.92	-0.64	1.00				
IP	0.93	0.62	-0.94	1.00			
M2	0.91	0.70	-0.93	0.94	1.00		
NK	0.71	0.46	-0.78	0.83	0.68	1.00	
R	-0.63	-0.43	0.71	-0.65	-0.77	-0.41	1.00

<sup>®</sup> This technique is also used in Miyao (2002).

<sup>®</sup> There is no common rule for deciding the ordering of variables. For example, Sims (1980) ordered variables as money, real GNP, unemployment, wage, price and import price innovations [M, Y, U, W, P, PM]. Sims (1986) ordered that as real GNP, real business fixed investment, GNP price deflator, M1, unemployment and Treasury-bill rates [Y, I, P, M, U, R]. Shioji (2000) made that as consumer price index, living expenditure of all households, new orders for machinery, industrial production, short-term interest rate, money stock (M2+CD), high-powered money and the Bank of Japan loans outstanding [P, S, O, Y, R, M, H, BL]. Miyao used that as the call rate, industrial production and the money base [r, y, m], [r, m, p (stock price), y], [EX (export), IM (import), e (exchange rate)], [EX, r, IM, e], and [EX, y, IM, e] in his literature. He checked other ordering and found that the results are similar. As provided by Christiano, Eichenbaum and Evans (1999), the response function of variable to monetary policy are invariant to the ordering of variables in  $X_t$  and  $X_t^c$ . I also estimated models with other ordering and obtained similar results (not reported here).

$$A_0 = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 & 0 & 0 \\ a_{31} & a_{32} & 1 & 0 & 0 & 0 & 0 \\ a_{41} & a_{42} & a_{43} & 1 & 0 & 0 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & 1 & a_{56} & a_{57} \\ a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & 1 & 0 \\ a_{71} & a_{72} & a_{73} & a_{74} & a_{75} & a_{76} & 1 \end{bmatrix}. \quad (21)$$

By these assumptions, we can model four possible choices when the Bank of Japan makes monetary policy:

R-model: observes no current value of the instrument variables :  $a_{56}, a_{57} = 0$  ;

R-M2-model: observes the current value only of  $M2$  :  $a_{56} \neq 0, a_{57} \neq 0$  ;

R-CR-model: observes the current value only of  $CR$  :  $a_{56} = 0, a_{57} \neq 0$  ;

R-M2-CR-model: observes both current values of  $M2$  and  $CR$  :  $a_{56}, a_{57} \neq 0$ .

The effects of shocks in different periods are also interested here, so these models are estimated with full sample and three sub-samples. The first sub-sample (1970:01-1985:12) is used to study shock's effects in which period the Bank of Japan implemented a variety of reforms. The second one (1980:01-1995:12) is used to study shock's effects while Japan experienced the forming and bursting of the economic bubble. And the last sub-sample (1995:01-2002:12) is used to study shock's effects after "low interest rate policy."

Data used here are monthly observations from 1970:01 to 2002:12. Industrial production, consumer price, exchange rate, the call rate, and the credit from monetary authorities are extracted from IFS database. Nikkei 225 average index and M2+CD are extracted from the homepage of the Bank of Japan. Except for the call rate, all series are expressed in logarithm and multiplied by 100.

The change rates of variables are interested mainly here. But in order to examine the stability of the series and prevent the existence of cointegration correlation, this section performs two unit root tests before estimating the models: the augmented Dickey Fuller test (ADF) and Dickey-Fuller test with GLS detrending (DFGLS). For both tests, the null hypothesis of a unit root against no unit root will not be rejected if the test statistic is larger than the critical values at a significant level. On contrary, it is rejected. As reported in Table 2, CR rejects null hypothesis at 5% level and the others show no rejection in level. Because CR series is  $I(0)$ , there is no cointegration among variables at 5% level. For the first difference, all variables strongly reject null hypothesis. It means that the first difference series of all variables are steady. Therefore, the SVAR can be constructed by the first differenced data without error-correction mechanism.

The optimum lag length is decided to 6 by calculating AIC statistics and SC statistics<sup>39</sup> with 6, 8, 10, 12, 18 lags. The results reported in Table 3 show that both of the AIC statistics and SC statistics are the smallest for 6 period lags.

The cumulative impulse responses of variables to one positive standard deviation innovations are calculated by Monte Carlo integration procedure with 500 replications, and up to 120 periods. The forecasting error variance decompositions are calculated for 48 periods.

<sup>39</sup> AIC: Akaike's information criterion. SC: Schwartz criterion.

Table 2 Unit root test

Variable	ADF		DF-GLS		
	Level(c-t)	First Dif.(c)	Level(c-t)	First dif.(c)	
IP	-1.82 (4)	-6.08*** (3)	-1.43 (4)	-3.66*** (3)	
CP	-2.68 (12)	-2.22 (13)	-1.24 (12)	-2.21** (13)	
EX	-2.21 (1)	-14.70*** (0)	-1.66 (1)	-14.60*** (0)	
NK	-0.54 (0)	-19.62*** (0)	-0.24 (0)	-17.88*** (0)	
R	-3.34 (3)	-7.51*** (2)	-3.20** (3)	-5.36*** (2)	
M2	-2.57 (12)	-1.99 (11)	-0.79 (12)	-2.14** (11)	
CR	-3.97**(12)	-4.40*** (12)	-3.96*** (13)	-3.11*** (12)	
Critical					
1%	-3.98	-3.44	-3.48	-2.57	
5%	-3.42	-2.87	-2.89	-1.94	
10%	-3.13	-2.57	-2.57	-1.62	

Note: This table reports the unit root test statistics (ADF and DF-GLS). It is assumed including constant and linear trend in level test and including constant in first difference test. “\*”, “\*\*” and “\*\*\*” denote rejecting null hypothesis of unit root existing at 10%, 5% and 1% level respectively. The lag lengths shown in the parentheses are chosen based on SIC (Schwarz Information Criterion).

Table 3 Lag length test

Sample Period		6	8	10	12	18
1970:01-2002:12	AIC	30.03	30.21	30.36	30.31	31.65
	SC	33.09	34.29	35.46	36.44	40.93
1970:01-1985:12	AIC	32.18	32.84	33.67	33.92	36.58
	SC	37.42	39.83	42.45	44.51	52.78
1980:01-1995:12	AIC	31.73	32.55	33.11	33.51	35.99
	SC	36.84	39.31	41.55	43.60	51.07
1995:01-2002:12	AIC	29.85	31.77	32.99	31.52	
	SC	37.89	42.43	46.26	47.41	

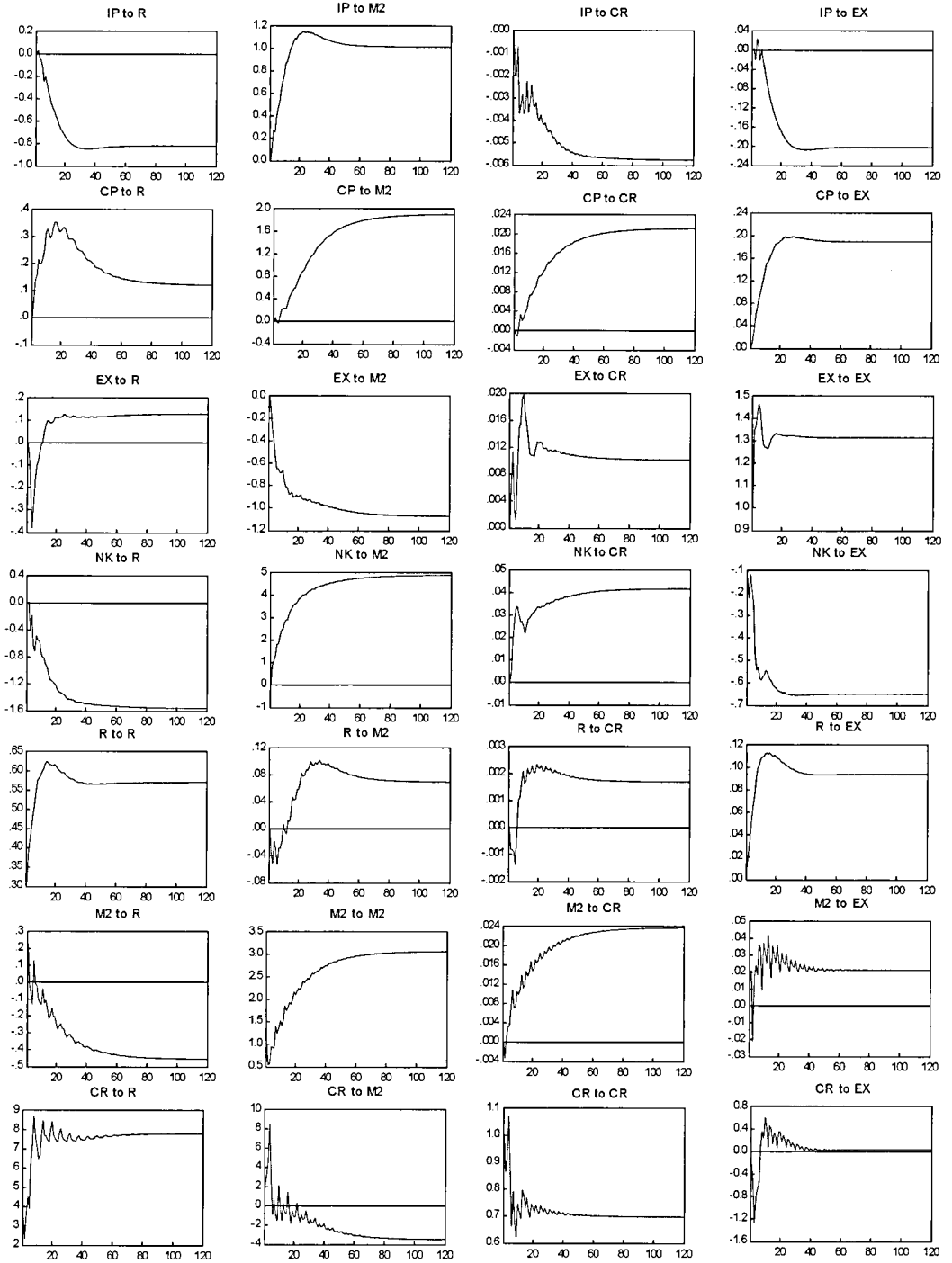
Note: AIC: Akaike's information criterion. SC: Schwartz criterion.

## 4.2 Empirical Results of Full Sample

Figure 3 shows the accumulated impulse responses of seven variables to shocks of three policy variables and exchange rate in R-model. The graphs in the first column are the responses to the call rate shock. 1) The call rate shock has a negative effect on *IP*. In the long-run, this negative effect is about  $-0.8$ . It is consistent with the result ( $-0.81$ ) calculated in Miyao (2002). 2) The second graph shows an unexpected pattern that the call rate shock has positive effect on consumer price. It means that consumer price jumps up after a tight monetary policy shock. It is called the “price puzzle”, which is frequently appeared in VAR analysis of monetary policy. 3) Exchange rate has a significant drop after the call rate shock, then comes back and exceeds the former level after about 10 periods. The reason of the decline in exchange rate may be

Figure 3 The dynamic effects of disturbances (Full sample, R-model)

Accumulated Response to Structural One S.D. Innovations: R-model, 1970:01-2002:12





considered as follows. If the interest rate of Japan is higher than other countries, in the short-run, foreign capitals will flow into Japan for benefits of the difference of interest rate between Japan and other countries. This flow will cause Japanese Yen's appreciation. The increase after 10 periods may be caused by other reasons, for example, the change of foreign central bank's monetary policy or the decline of domestic output in the long-run, etc. 4) The shock of the call rate causes a fall of stock prices. If the call rate jumps up, domestic individual likely holds more currency than before. For this reason, the capital invested in stock market will decline and stock prices drop down. From the 4<sup>th</sup> graph, we can also observe that the long-run negative effect on stock prices is about  $-1.6$ . It corresponds to the result of Miyao (2002) again (it is about  $-1.5$  in there). 5) The call rate shock has a positive effect on itself. 6) The call rate being raised means a tight monetary policy. To correspond to this policy, money supply will be reduced. The "liquidity puzzle" is not found here. 7) The 7<sup>th</sup> graph also shows an unexpected result that the call rate shock has a positive effect on credit from central bank. Generally, rising of the call rate causes a rising of capital cost, the credit from central bank should decrease.

The graphs in column 2 display the response to money supply shock. Because a positive shock of money supply is equivalent to a negative shock of the call rate, both of them mean the loose monetary policy. Therefore, most of impulse responses in column 2 are opposite to those in column 1. The 1<sup>st</sup> and 2<sup>nd</sup> graphs exhibit perfect curves in which *IP* or *CP* has obvious and persistent rising after a positive money supply shock and the "price puzzle" is not found here. Because money supply shock is assumed the unique shock here (no shock exists in *R*), it leads *IP* to rises, and then *EX* rises (the 3<sup>rd</sup> graph). Loose money supply also results in a rising of stock price as showed in the 4<sup>th</sup> graph. The 5<sup>th</sup> graph shows that the call rate drops for 12 periods and then rises. *CR* also has a positive reaction in short-run for about 15 periods (the 6<sup>th</sup> graph).

In general, rising of credit from central bank also means loose monetary policy. Its effect on other variables should be same as the effects of a positive money supply shock. The graphs (except for the first one) in column 3 exhibit an expected pattern. However, from the graphs in this column, it can be found that these effects are very small. The absolute values of response of stock price is 0.04 and the others are smaller than 0.025. The results of variance decomposition (will be described later) also show that the contributions of *CR* on the other variables are very small.

The graphs in column 4 explain how exchange rate's shock affects the economic variables and policy variables. A positive change in exchange rate is equivalent to the depreciation of Japanese Yen. After it occurred, output jumps up with a small range at once, and drops quickly after 6 periods. Its long-run effect on *IP* is  $-0.2$ . Consumer price has a positive response (0.2). because the depreciation of Yen raises import prices, so partly raises consumer price index. The 4<sup>th</sup> graph shows that positive shock in exchange rate decreases the stock prices. The reasons should be explained as follows. Firstly, the depreciation of Yen decreases the amount of net assets, so domestic investors possibly cut their investment in Japanese stock market. Secondly, when the foreign investors invest their capital into Japanese stock market, they care about not only the returns counted by Yen, but also the returns counted by their national currency. If exchange rate is stable, the profit is decided only by the projects they invested. If exchange rate is not stable, the capital return is correlated with exchange rate. Thus, in the long-run, the depreciation of Yen may decrease the return of foreign capitals and then foreign capitals in Japanese stock market will follow out. The call rate and money supply positively respond this shock (about 0.1 and 0.02 respectively). If ignore the response of

money supply (because it is very small), these results support Miyao (2003, 2006)<sup>11</sup>. The last graph in column 4 tells us that the exchange rate disturbance leads credit from central bank to fluctuate in the short-run, but has no persistent effect on it.

Figure 4 describes the estimated dynamic responses to the shocks in R-M2-model. In column 1, the 1<sup>st</sup>, 3<sup>rd</sup>, 4<sup>th</sup> and 6<sup>th</sup> graphs are similar to those in R-model. However, the strength of the effects are larger (*IP*:  $-1.0$  vs.  $-0.8$ , *EX*:  $+0.3$  vs.  $+0.1$ , *NK*:  $-2.5$  vs.  $-1.6$ , *M2*:  $-1.0$  vs.  $-0.4$ ). It represents that the call rate shock in R-M2-model affects output, exchange rate, stock prices and money supply with the same pattern but larger power. The 2<sup>nd</sup> graph displays a better result that the “price puzzle” is mitigated. To respond the shock in the call rate, consumer price rises for 10 periods, then drops to zero after 25 periods, and finally stops at  $-0.25$ . It means that a positive shock in the call rate has a negative effect on prices in the long-run, but not a positive effect as shown in R-model. The 5<sup>th</sup> and 7<sup>th</sup> graph exhibit the same effects in both of size and pattern as that in R-model. In column 2, the 5<sup>th</sup> graph shows that the long-run effect of money supply disturbance on the call rate is smaller ( $+0.2$ ) than that in R-model ( $+0.6$ ). It is not surprise that the effect of disturbance becomes smaller, because policy maker set the interest rate policy by referring the current information of money supply. Other graphs are identical to those in R-model. All graphs in column 3 and column 4 show the same results as those in R-model.

All shock's dynamic effects estimated from R-CR-model and R-M2-CR-model are completely equivalent to that from R-model and R-M2-model respectively, so they are not reported here. It represents that monetary policy have the same effects on economic variables, whether it is set by referring to the credit from central bank or not.

In order to verify above conclusions, the forecasting error variance decomposition of non-policy variables are calculated and summarized in Table 4.

*R* has significant contributions to *IP*, *CP*, *EX* and *NK* in four models. The values of *R* in R-model and R-M2-model are almost identical to those in R-CR-model and R-M2-CR-model, respectively. The values of *R* on *IP* and *NK* in R-model (or R-CR-model) are smaller than those in R-M2-model (or R-M2-CR-model). On the other hand, the values of *R* on *CP* and *EX* in R-model (or in R-CR-model) are larger than those in R-M2-model (or R-M2-CR-model) until 24 periods, and then become smaller afterwards. The values of *EX* in R-model (or R-CR-model) are larger than those in R-M2-model (or R-M2-CR-model). Similarly, *M2* has significant contributions to *IP*, *CP*, *EX* and *NK* too. The values of *M2* in R-model and R-M2-model are almost identical to those in R-CR-model and R-M2-CR-model, respectively. The contributions of *M2* on *IP*, *CP*, and *NK* in R-M2-model (or R-CR-model) are larger than those in R-M2-CR-model (or R-M2-CR-model). The contributions of *M2* on *EX* in R-model (or R-CR-model) are smaller than those in R-M2-model (or R-M2-CR-model). *M2*'s contribution to *NK* is obviously large (more than 29%). All values of *EX* in four models are almost equivalent. The values of *EX* on *NK* are relativity significant (2.39-3.09), but the others are relativity small (0.01-0.44). The contributions of *CR* are very small ( $< 0.02$ ).

The variance decomposition analysis supports the results obtained from impulse response function. Therefore, the results of full sample study can be summarized as follows. The call rate shock and money

<sup>11</sup> Miyao studied the effects of Yen's appreciation. As explained in his literature (2006, pp61), to respond Yen's appreciation, Japanese interest rate lowers and output will be extended. This can be considered as a loose monetary policy.

Figure 4 The dynamic effects of disturbances (Full sample, R-M2-model)

Accumulated Response to Structural One S.D. Innovations: R-M2-model, 1970:01-2002:12

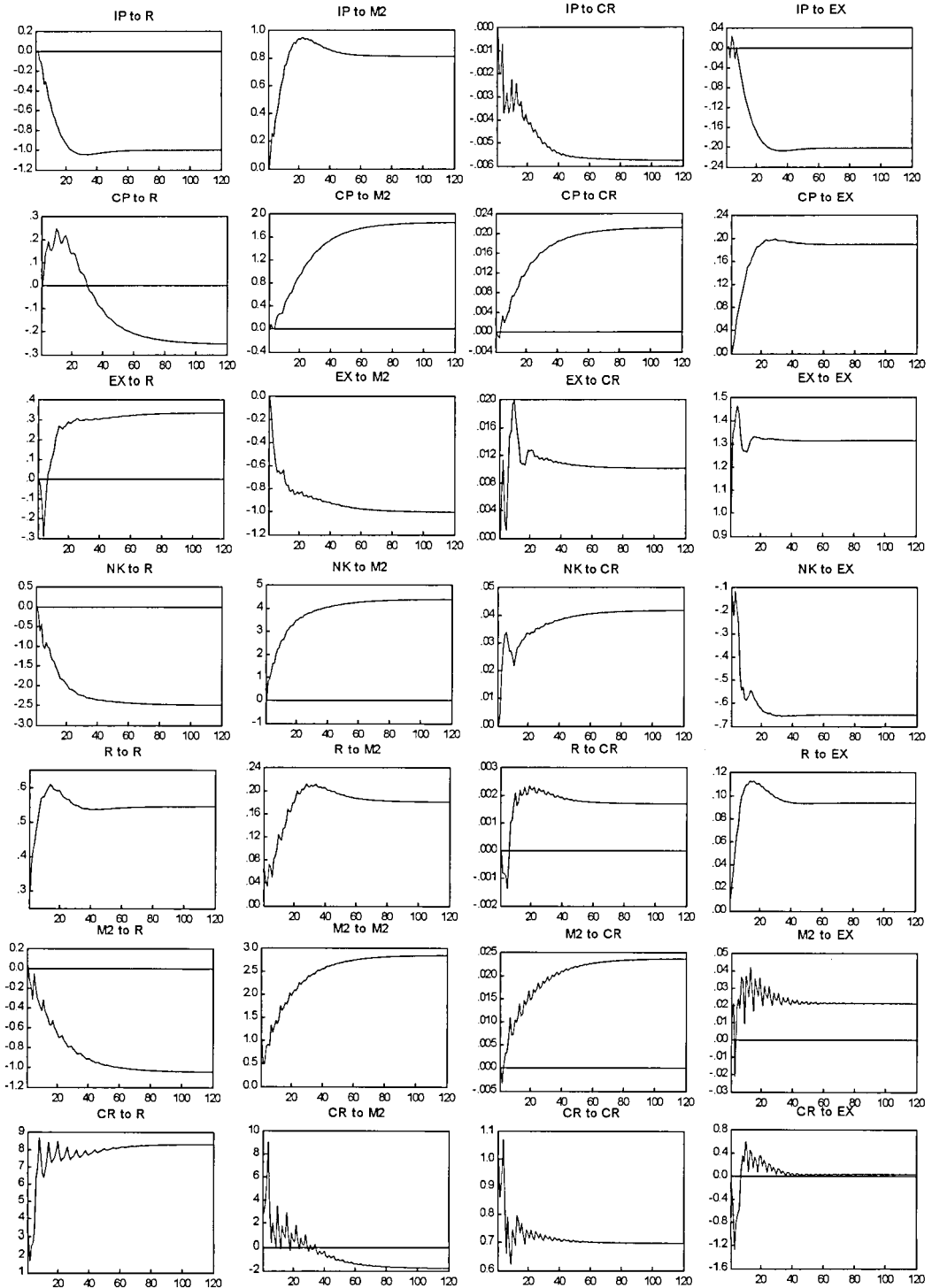


Table 4 The variance decompositions (1970:01-2002:12)

Period	R-model							R-M2model							
	IP	CP	EX	NK	R	M2	CR	IP	CP	EX	NK	R	M2	CR	
IP	6	88.49	4.73	0.27	0.13	1.85	4.53	0.001	88.66	4.74	0.27	0.13	2.56	3.65	0.001
	12	80.56	9.60	0.39	0.17	2.86	6.42	0.001	80.77	9.62	0.39	0.17	4.04	5.01	0.001
	24	78.31	10.78	0.44	0.16	3.41	6.90	0.001	78.53	10.81	0.44	0.16	4.77	5.29	0.001
	36	78.24	10.81	0.44	0.16	3.42	6.93	0.001	78.46	10.83	0.44	0.16	4.79	5.32	0.001
	48	78.22	10.81	0.44	0.16	3.42	6.94	0.001	78.44	10.84	0.44	0.16	4.79	5.33	0.001
CP	6	0.26	94.70	0.15	0.01	1.18	3.70	0.001	0.26	94.84	0.15	0.01	1.15	3.59	0.001
	12	0.48	92.50	0.21	0.01	1.56	5.24	0.002	0.48	92.70	0.21	0.01	1.40	5.21	0.002
	24	0.53	89.95	0.21	0.02	1.65	7.64	0.002	0.53	90.23	0.21	0.02	1.64	7.37	0.002
	36	0.53	88.97	0.21	0.02	1.70	8.57	0.002	0.53	89.28	0.21	0.02	1.81	8.15	0.002
	48	0.53	88.71	0.21	0.02	1.72	8.81	0.002	0.53	89.02	0.21	0.02	1.87	8.35	0.002
EX	6	6.05	4.63	77.56	0.07	5.52	6.15	0.014	6.07	4.65	77.75	0.07	4.84	6.61	0.014
	12	6.90	6.15	74.24	0.07	5.92	6.70	0.017	6.92	6.17	74.43	0.07	5.39	7.00	0.018
	24	6.91	6.82	73.15	0.08	5.92	7.11	0.018	6.93	6.84	73.36	0.08	5.45	7.33	0.018
	36	6.90	7.01	72.92	0.08	5.91	7.17	0.018	6.92	7.03	73.13	0.08	5.44	7.39	0.018
	48	6.89	7.04	72.88	0.08	5.91	7.19	0.018	6.91	7.06	73.09	0.08	5.44	7.40	0.018
NK	6	7.95	8.76	3.04	31.62	14.40	34.22	0.011	8.06	8.88	3.08	32.06	18.01	29.89	0.011
	12	7.40	18.11	2.54	24.81	13.44	33.70	0.010	7.50	18.35	2.58	25.14	16.38	30.04	0.010
	24	7.16	18.66	2.41	23.20	13.37	35.19	0.009	7.27	18.92	2.45	23.53	16.82	31.00	0.010
	36	7.13	18.77	2.40	23.02	13.32	35.36	0.009	7.23	19.03	2.43	23.35	16.81	31.13	0.010
	48	7.12	18.79	2.39	22.98	13.31	35.40	0.009	7.22	19.06	2.43	23.31	16.80	31.17	0.010
Period	R-CR-model							R-M2-CR-model							
	IP	CP	EX	NK	R	M2	CR	IP	CP	EX	NK	R	M2	CR	
IP	6	88.49	4.74	0.27	0.13	1.85	4.53	0.001	88.64	4.77	0.27	0.13	2.59	3.60	0.001
	12	80.55	9.61	0.39	0.17	2.86	6.42	0.001	80.74	9.68	0.39	0.17	4.09	4.94	0.001
	24	78.30	10.79	0.44	0.16	3.40	6.90	0.001	78.49	10.87	0.44	0.16	4.83	5.20	0.001
	36	78.23	10.82	0.44	0.16	3.42	6.93	0.001	78.42	10.90	0.44	0.16	4.84	5.23	0.001
	48	78.21	10.82	0.44	0.16	3.42	6.94	0.001	78.40	10.91	0.44	0.16	4.85	5.24	0.001
CP	6	0.26	94.70	0.15	0.01	1.18	3.70	0.001	0.26	94.85	0.15	0.01	1.15	3.57	0.001
	12	0.48	92.50	0.21	0.01	1.56	5.24	0.002	0.48	92.71	0.21	0.01	1.40	5.19	0.002
	24	0.53	89.95	0.21	0.02	1.65	7.64	0.002	0.53	90.25	0.21	0.02	1.65	7.34	0.002
	36	0.53	88.97	0.21	0.02	1.70	8.57	0.002	0.53	89.30	0.21	0.02	1.83	8.11	0.002
	48	0.53	88.71	0.21	0.02	1.72	8.81	0.002	0.53	89.05	0.21	0.02	1.89	8.31	0.002
EX	6	6.05	4.64	77.56	0.07	5.52	6.15	0.014	6.07	4.65	77.76	0.07	4.81	6.62	0.014
	12	6.90	6.16	74.23	0.07	5.92	6.70	0.017	6.92	6.18	74.44	0.07	5.37	6.99	0.018
	24	6.91	6.82	73.15	0.08	5.92	7.11	0.018	6.93	6.85	73.37	0.08	5.43	7.33	0.018
	36	6.90	7.01	72.92	0.08	5.91	7.17	0.018	6.92	7.04	73.14	0.08	5.43	7.38	0.018
	48	6.89	7.04	72.88	0.08	5.91	7.19	0.018	6.91	7.07	73.10	0.08	5.43	7.40	0.018
NK	6	7.95	8.77	3.04	31.62	14.40	34.21	0.011	8.06	8.96	3.09	32.07	18.19	29.62	0.011
	12	7.39	18.12	2.54	24.80	13.43	33.70	0.010	7.50	18.43	2.58	25.16	16.53	29.80	0.010
	24	7.16	18.67	2.41	23.20	13.37	35.18	0.009	7.27	19.00	2.45	23.55	17.00	30.73	0.010
	36	7.13	18.78	2.40	23.01	13.32	35.35	0.009	7.24	19.11	2.43	23.36	17.00	30.86	0.010
	48	7.12	18.80	2.39	22.98	13.31	35.39	0.009	7.23	19.13	2.43	23.32	16.98	30.90	0.010

supply shock have significant effects on economic variables. Exchange rate shock has significant effects on stock prices but limited effects on other variables. The effects of credit from central bank on economic variables are very small. There is no variety in shock' effects whether credit from central bank is considered in model or not. R-M2 model are more significant to fit full sample than R-model because R-M2-model does not suffer the "price puzzle" and the "liquidity puzzle". It seems that the Bank of Japan conducts monetary policy by controlling both of the call rate and the money supply in whole period.

### 4.3 Empirical Results of Sub-Samples

In this section, four models are estimated by using the same identifying condition and three sub-samples. Regrettably, some of the estimations can not be finished. The possible reason is considered that the length of data is not enough (because the same estimations are successful with full sample).

Figures 5 and 6 exhibit the dynamic responses of variables, which are obtained by estimating R-model and R-M2-model with the first sub-sample (1970:01-1985:12). Though most graphs in two Figures are similar to those from full sample, it is necessary to pay attentions to some differences. In two Figures, the 3<sup>rd</sup> graph of column 1 shows that exchange rate has a negative reaction to a positive shock of the call rate. This is equivalent to Miyao (2003). The 1<sup>st</sup>, 4<sup>th</sup>, and 5<sup>th</sup> graphs in column 2 show that  $IP$ ,  $NK$  and  $R$  jump originally after money supply shock, then drop and stop at constant level. The “liquidity puzzle” is not distinct. The “price puzzle” appears again in Figure 5 but does not in Figure 6. Comparing the effects of exchange rate shock in these two Figures with those in full sample, no obvious variety is observed. It means that the effect of exchange rate shock does not change for changing the sample period. This result is similar to Miyao (2003) again. The effects of credit from central bank shock are very small too.

Figure 7 displays the results of R-model and R-M2-model about the second sub-sample (1980:01-1995:12). It is interesting that the accumulated dynamic responses of two models are almost equivalent, so only one is reported here.

In column 1, the 3<sup>rd</sup> graph displays that tight monetary policy has a negative effect on exchange rate whether in the long-run or in the short-run. This is identical to R-model for the first sub-sample, but different from that for full sample. The 4<sup>th</sup> graph is different from anyone of the former cases. It is difficult to explain that tight monetary policy leads stock price to rise in the long-run. One possible reason may be that in the period of “bubble economy”, the negative effect of tight monetary policy is not enough to offset the positive effects from some other factors which are not introduced in the models. In column 2, the 3<sup>rd</sup> graph shows that money supply shock has temporarily negative effect on exchange rate. The 1<sup>st</sup> graph in column 4 tells us that the shock of Yen' depreciation leads output to rise.

Figures 8 and 9 represent the results of R-model, R-M2-model and R-CR-model about the third sub-sample (1995:01-2002:12), respectively. Because the results of R-model are completely identical to that of R-CR-model, they are reported using one figure. In Figure 8, most results are similar to those in full sample. However, in column 1, the 1<sup>st</sup> graph represents that output has a positive reaction to the call rate shock. The second one reports that a positive shock in the call rate has a negative effect on price level, the “price puzzle” disappears here. The “liquidity puzzle” appears in the 5<sup>th</sup> graph of column 2, but it is not obvious. In Figure 9, the 1<sup>st</sup> graph is similar to Figure 8. It displays unexpected result that output reacts positively to the call rate shock. The second one shows the “price puzzle” again but its size is very small (+0.04). The 1<sup>st</sup> graph in column 2 shows that after money supply shock, output reacts positively until about 20 periods, but this reaction is negative in the long-run. There is no obvious variety in the effects of  $EX$  and  $CR$  shocks.

Tables 5 to 7 report the forecasting error variance decompositions yielded from three sub-samples. From these tables, we can extract some common results to support those from full sample. The contributions of  $R$  and  $M2$  to non-policy variables are significant. The contributions of credit from central bank are very small (<0.03%). Exchange rate shock's contributions to non-policy variables are not large (<1.5%). The other fact

Figure 5 The dynamic effects of disturbances (First sub-sample, R-model)

Accumulated Response to Structural One S.D. Innovations: R-model, 1970:01-1985:12

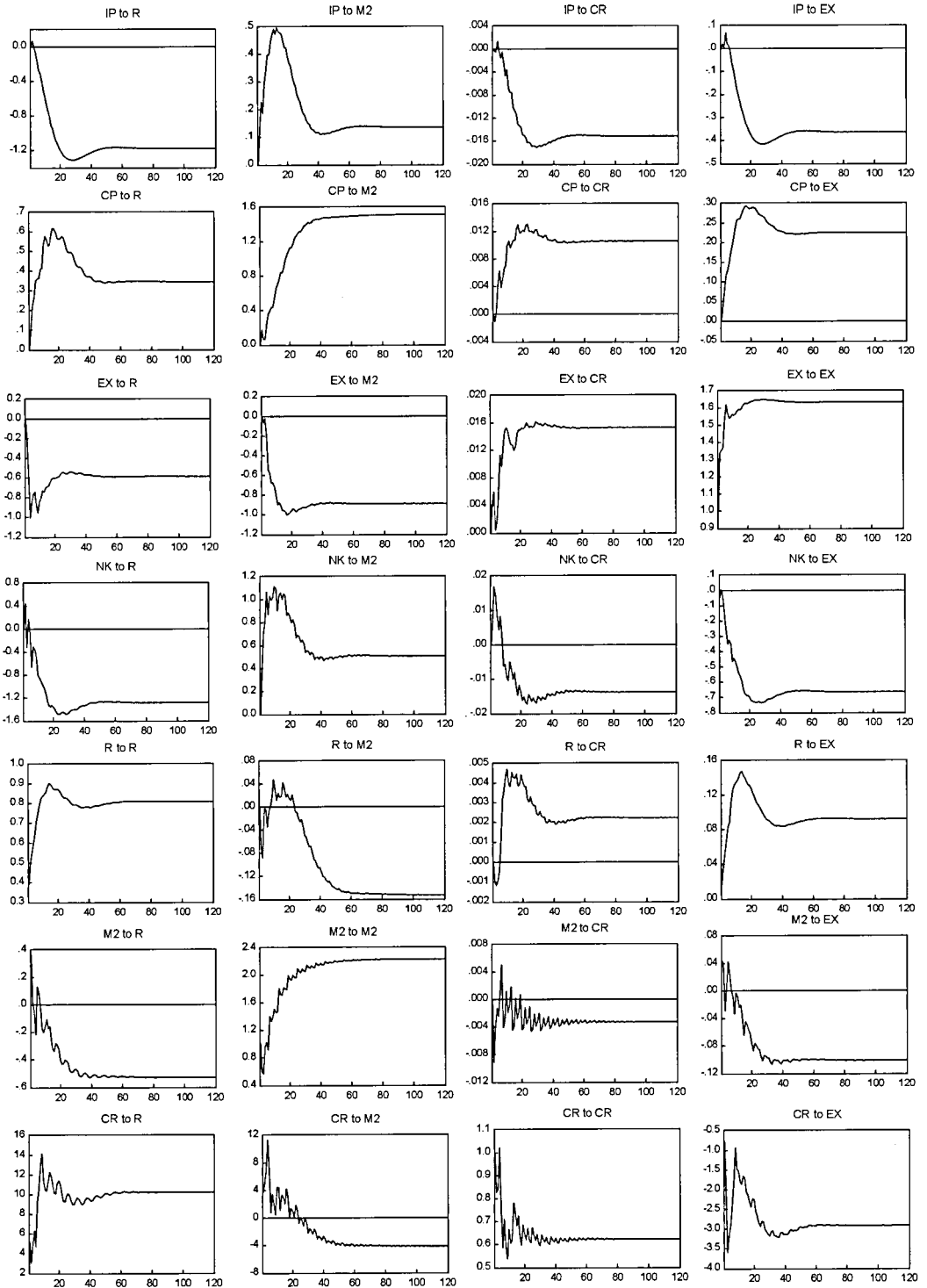


Figure 6 The dynamic effects of disturbances (First sub-sample, R-M2-model)

Accumulated Response to Structural One S.D. Innovations: R-M2-model, 1970:01-1985:12

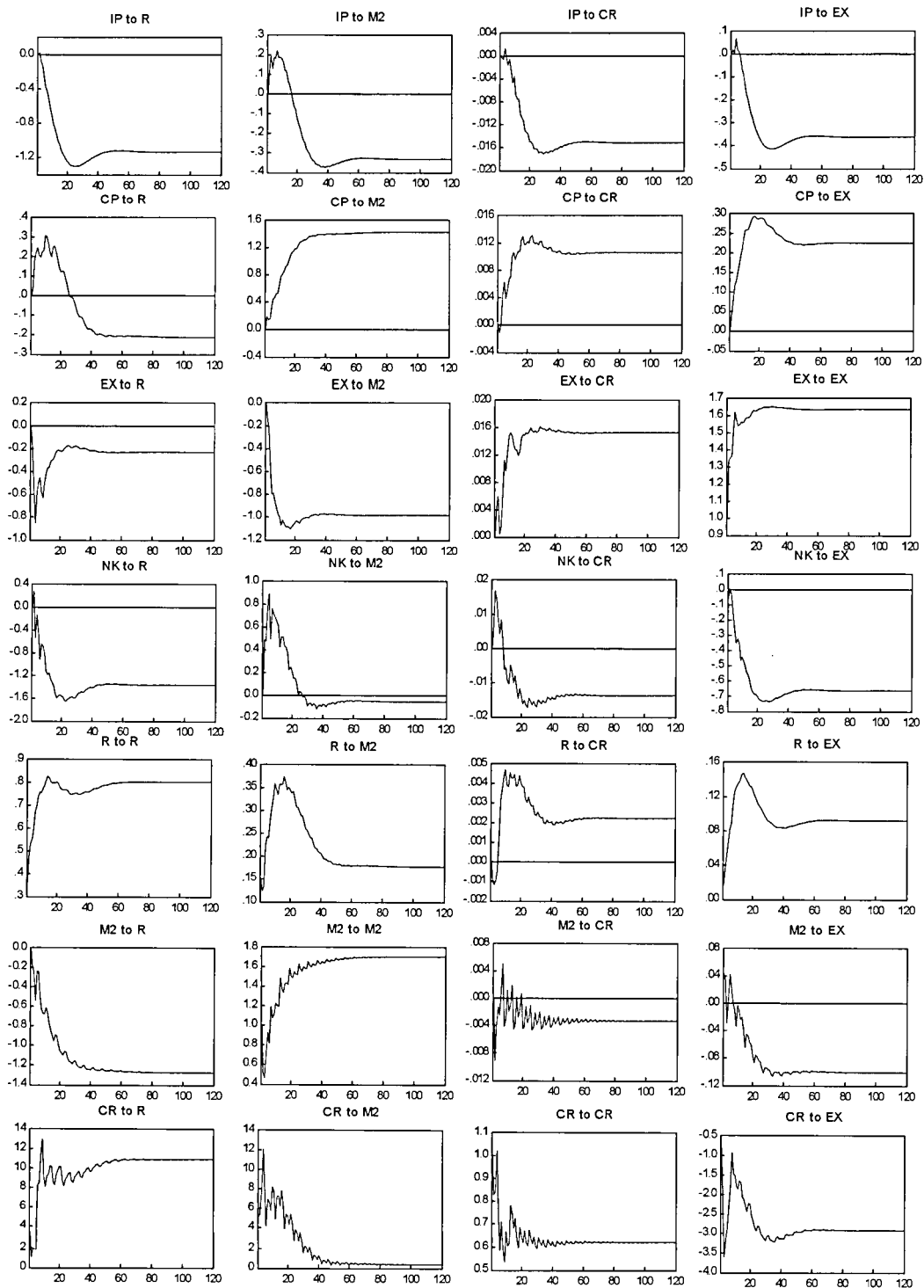


Figure 7 The dynamic effects of disturbances (Second sub-sample, R and R-M2-model)

Accumulated Response to Structural One S.D. Innovations: R-model and R-M2-model, 1980:01-1995:12

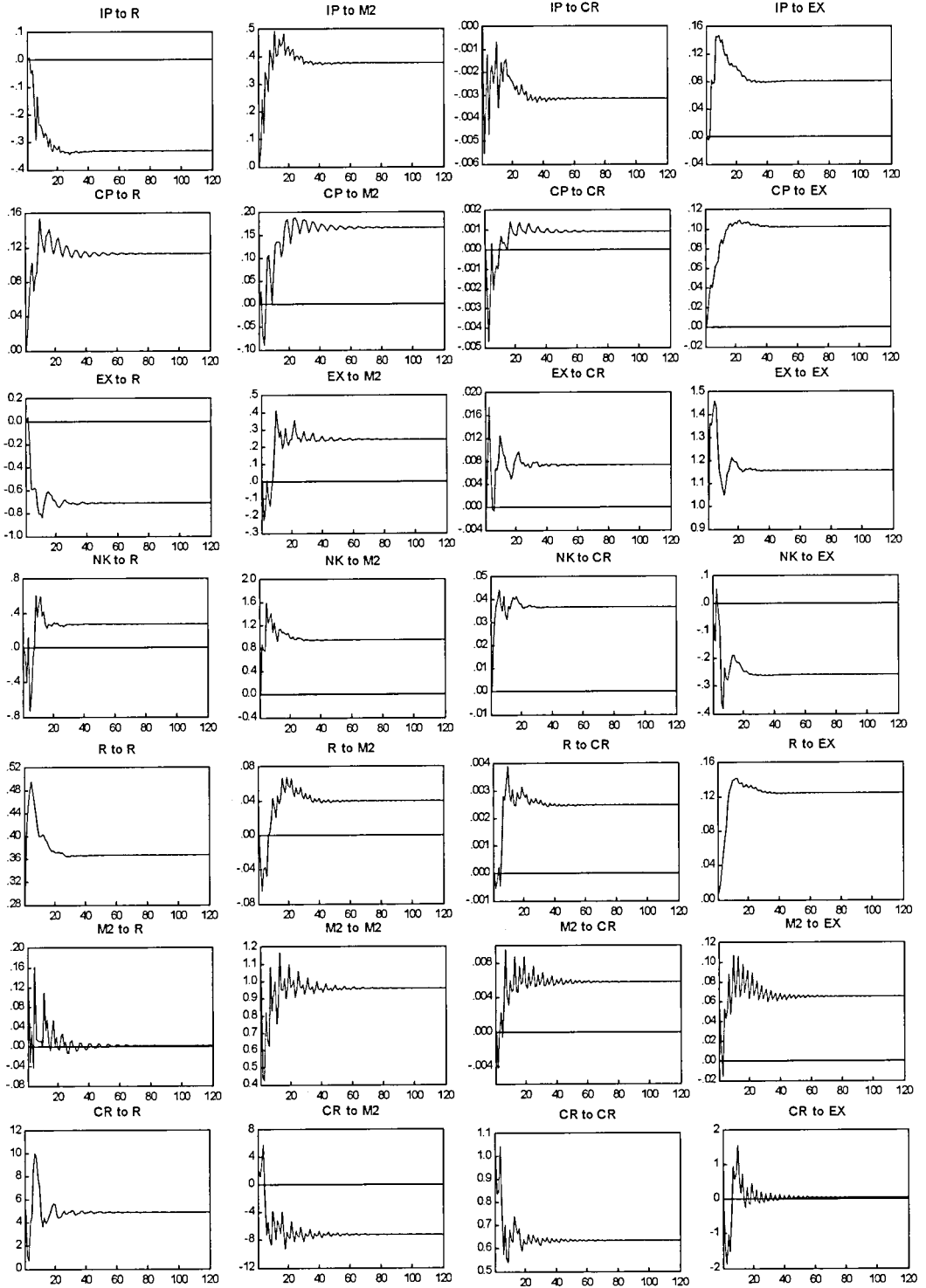




Figure 8 The dynamic effects of disturbances (Third sub-sample, R and R-CR-model)

Accumulated Response to Structural One S.D. Innovations: R-model and R-CR-model, 1995:01-2002:12

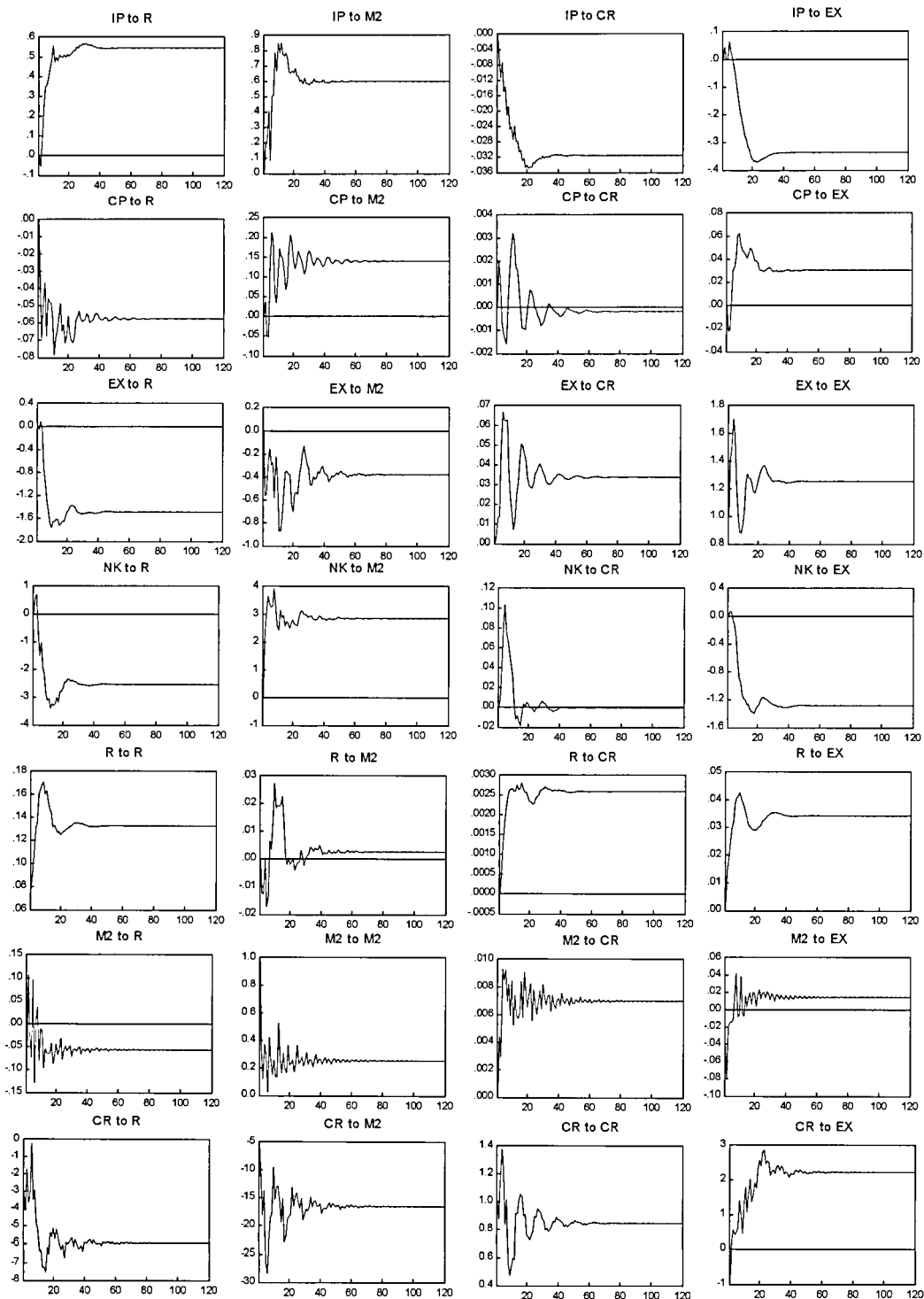
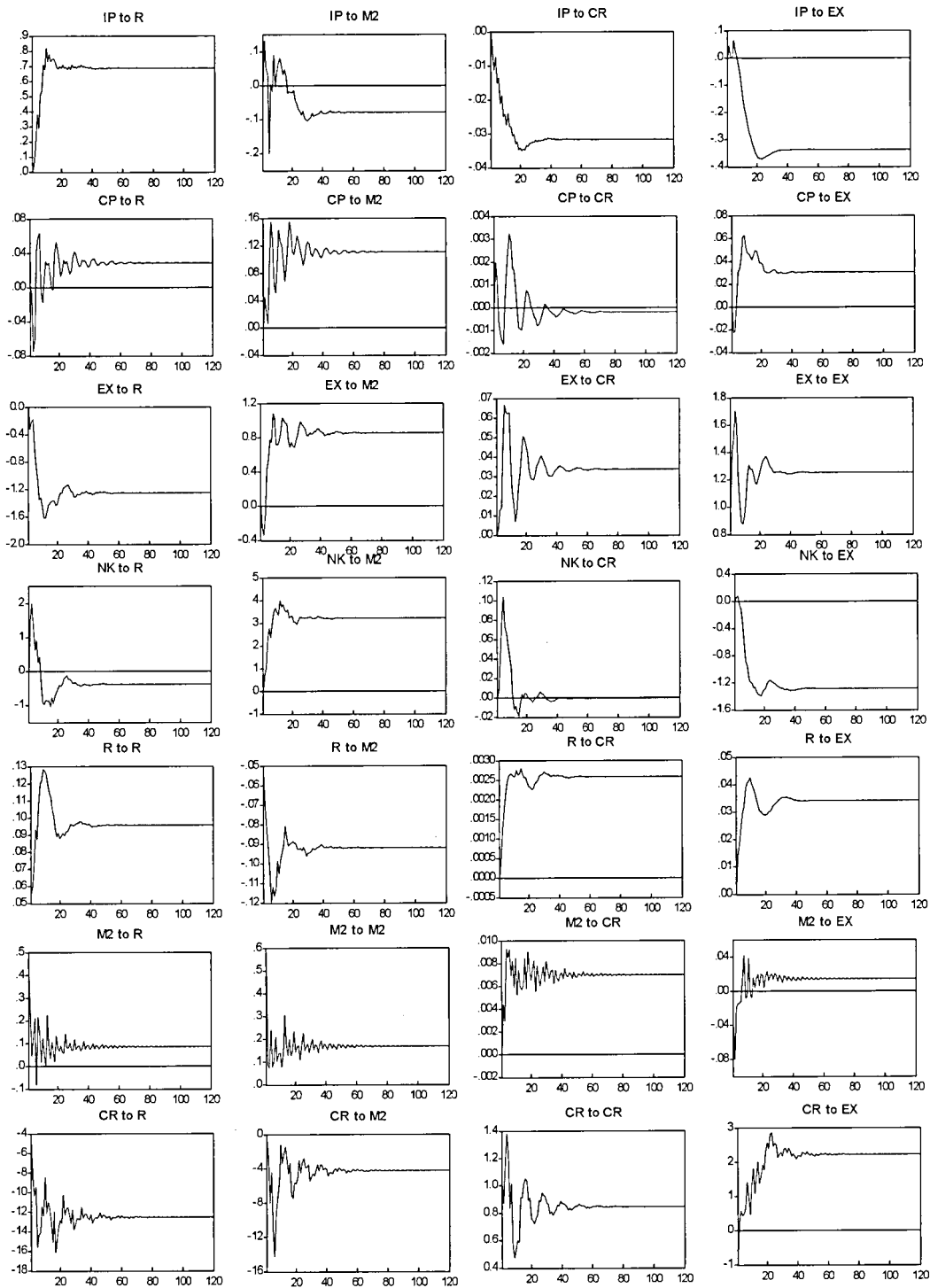


Figure 9 The dynamic effects of disturbances (Third sub-sample, R-M2-model)

Accumulated Response to Structural One S.D. Innovations: R-M2-model, 1995:01-2002:12



can be observed here is that, the contributions of  $R$  and  $M2$  in  $CP$  are largest in first sub-sample and smallest in the second. These mean that the power of monetary policy affecting consumer price are largest in first sub-sample period and are smallest in second sub-sample period.

Table 5 The variance decompositions (1970:01-1985:12)

Period	R-model							R-M2-model							
	IP	CP	EX	NK	R	M2	CR	IP	CP	EX	NK	R	M2	CR	
IP	6	80.67	13.13	0.50	0.60	2.32	2.78	0.001	80.99	13.19	0.50	0.60	2.86	1.86	0.001
	12	75.43	15.50	0.93	0.62	4.56	2.96	0.002	75.76	15.57	0.94	0.62	5.15	1.97	0.002
	24	73.21	15.74	1.15	0.60	6.17	3.13	0.003	73.54	15.82	1.15	0.60	6.28	2.61	0.003
	36	72.97	15.80	1.15	0.60	6.18	3.29	0.003	73.32	15.88	1.15	0.60	6.31	2.73	0.003
CP	6	1.67	87.90	0.43	0.16	2.77	7.07	0.002	1.69	88.81	0.43	0.16	2.13	6.78	0.002
	12	2.08	84.53	0.58	0.18	3.94	8.69	0.003	2.11	85.61	0.58	0.19	2.56	8.95	0.003
	24	2.08	82.41	0.57	0.19	4.17	10.57	0.004	2.11	83.69	0.58	0.19	3.28	10.15	0.004
	36	2.14	81.97	0.58	0.19	4.34	10.78	0.004	2.17	83.27	0.59	0.19	3.59	10.18	0.004
EX	6	3.09	10.36	58.10	0.27	20.63	7.54	0.004	3.12	10.48	58.74	0.27	17.14	10.24	0.004
	12	4.36	16.00	51.34	0.37	20.08	7.85	0.005	4.41	16.19	51.92	0.38	17.23	9.87	0.005
	24	4.62	17.66	49.79	0.37	19.67	7.88	0.005	4.67	17.88	50.36	0.38	16.98	9.74	0.005
	36	4.62	17.78	49.67	0.37	19.66	7.90	0.005	4.67	17.99	50.24	0.38	16.97	9.75	0.005
NK	6	5.81	15.31	1.09	28.29	39.55	9.94	0.006	5.90	15.54	1.11	28.70	34.96	13.78	0.006
	12	10.77	20.85	1.19	22.27	35.67	9.24	0.007	10.92	21.14	1.20	22.57	31.10	13.06	0.007
	24	10.67	23.41	1.25	20.68	33.99	9.98	0.009	10.83	23.76	1.26	20.98	29.88	13.27	0.009
	36	10.61	23.80	1.24	20.48	33.72	10.14	0.009	10.77	24.16	1.26	20.78	29.70	13.32	0.009
48	10.61	23.87	1.24	20.43	33.67	10.17	0.009	10.77	24.23	1.26	20.73	29.67	13.33	0.009	

Table 6 The variance decompositions (1980:01-1995:12)

Period	R-model							R-M2-model							
	IP	CP	EX	NK	R	M2	CR	IP	CP	EX	NK	R	M2	CR	
IP	6	82.31	8.94	0.42	0.20	2.15	5.99	0.004	82.32	8.93	0.42	0.20	2.12	6.02	0.004
	12	70.44	17.13	0.60	0.18	3.69	7.95	0.004	70.44	17.12	0.60	0.18	3.64	8.00	0.004
	24	68.12	18.80	0.60	0.18	3.84	8.46	0.004	68.12	18.80	0.60	0.18	3.79	8.51	0.004
	36	67.98	18.87	0.60	0.18	3.84	8.52	0.004	67.98	18.87	0.60	0.18	3.79	8.57	0.004
CP	6	0.42	96.53	0.07	0.01	0.36	2.60	0.003	0.42	96.53	0.07	0.01	0.36	2.61	0.003
	12	0.61	95.04	0.10	0.01	0.59	3.64	0.003	0.61	95.04	0.10	0.01	0.58	3.65	0.003
	24	0.63	94.73	0.11	0.02	0.63	3.89	0.003	0.63	94.73	0.11	0.02	0.62	3.90	0.003
	36	0.63	94.65	0.11	0.02	0.64	3.96	0.003	0.63	94.65	0.11	0.02	0.63	3.97	0.003
EX	6	8.39	28.20	49.42	0.08	9.74	4.16	0.014	8.39	28.20	49.43	0.08	9.67	4.22	0.014
	12	7.92	35.24	40.94	0.09	9.07	6.74	0.014	7.92	35.23	40.94	0.09	9.00	6.80	0.014
	24	7.44	38.55	37.78	0.09	8.68	7.45	0.013	7.44	38.55	37.78	0.09	8.61	7.51	0.013
	36	7.35	39.17	37.24	0.09	8.59	7.54	0.013	7.35	39.17	37.25	0.09	8.53	7.61	0.013
NK	6	13.36	45.25	1.40	10.84	12.22	16.92	0.006	13.36	45.26	1.40	10.84	12.08	17.05	0.006
	12	11.89	47.67	1.34	8.74	15.04	15.31	0.007	11.89	47.68	1.34	8.74	14.90	15.45	0.007
	24	11.56	48.22	1.31	8.45	15.20	15.25	0.007	11.56	48.23	1.31	8.45	15.06	15.39	0.007
	36	11.55	48.24	1.31	8.44	15.19	15.26	0.007	11.55	48.24	1.31	8.44	15.05	15.39	0.007
48	11.55	48.24	1.31	8.44	15.19	15.26	0.007	11.55	48.25	1.31	8.44	15.05	15.39	0.007	

Table 7 The variance decompositions (1995:01-2002:12)

Period	R-model							R-M2-model							
	IP	CP	EX	NK	R	M2	CR	IP	CP	EX	NK	R	M2	CR	
IP	6	67.39	8.86	0.50	0.34	3.31	19.59	0.008	74.59	9.80	0.55	0.38	7.29	7.38	0.009
	12	48.21	28.95	0.67	0.42	2.99	18.75	0.010	53.11	31.89	0.74	0.46	7.66	6.12	0.011
	24	44.60	33.50	0.76	0.40	2.83	17.90	0.011	48.92	36.74	0.84	0.44	7.24	5.82	0.012
	36	44.37	33.66	0.76	0.40	2.83	17.97	0.011	48.68	36.92	0.84	0.44	7.29	5.82	0.012
	48	44.34	33.68	0.76	0.40	2.83	17.98	0.011	48.65	36.95	0.84	0.44	7.30	5.82	0.012
CP	6	0.35	94.85	0.16	0.01	0.33	4.30	0.001	0.36	96.90	0.16	0.01	1.33	1.24	0.001
	12	0.70	92.52	0.19	0.01	0.39	6.19	0.001	0.73	95.42	0.20	0.01	1.72	1.92	0.001
	24	0.75	91.81	0.18	0.01	0.42	6.82	0.001	0.78	95.00	0.19	0.01	1.82	2.19	0.001
	36	0.77	91.68	0.18	0.01	0.42	6.93	0.001	0.79	94.92	0.19	0.01	1.84	2.24	0.001
	48	0.77	91.66	0.18	0.01	0.42	6.95	0.001	0.80	94.91	0.19	0.01	1.84	2.25	0.001
EX	6	10.79	62.51	15.47	0.31	6.08	4.83	0.018	11.05	64.03	15.85	0.32	4.00	4.73	0.018
	12	7.87	67.72	11.46	0.24	5.70	6.99	0.019	8.15	70.14	11.87	0.24	4.16	5.43	0.020
	24	7.65	68.73	10.35	0.21	5.32	7.72	0.021	7.95	71.45	10.75	0.22	4.03	5.58	0.022
	36	7.54	68.90	10.11	0.21	5.23	7.99	0.021	7.85	71.72	10.53	0.22	4.03	5.64	0.022
	48	7.53	68.89	10.09	0.21	5.22	8.04	0.021	7.84	71.73	10.51	0.21	4.03	5.65	0.022
N	6	4.48	76.74	0.11	1.87	5.87	10.93	0.008	4.73	81.11	0.12	1.97	6.83	5.23	0.008
	12	4.89	72.56	0.45	1.69	7.76	12.65	0.009	5.21	77.39	0.48	1.80	8.51	6.61	0.010
	24	4.71	73.04	0.45	1.58	7.74	12.47	0.009	5.01	77.83	0.48	1.69	8.27	6.71	0.010
	36	4.69	73.10	0.45	1.57	7.70	12.49	0.009	5.00	77.89	0.48	1.67	8.25	6.70	0.010
	48	4.69	73.09	0.45	1.57	7.69	12.50	0.009	5.00	77.89	0.48	1.67	8.25	6.71	0.010
Period	R-CR-model							R-M2-CR-model							
	IP	CP	EX	NK	R	M2	CR	IP	CP	EX	NK	R	M2	CR	
IP	6	67.40	8.86	0.50	0.34	3.31	19.59	0.008							
	12	48.21	28.95	0.67	0.42	2.99	18.75	0.010							
	24	44.60	33.50	0.76	0.40	2.83	17.90	0.011							
	36	44.37	33.66	0.76	0.40	2.83	17.97	0.011							
	48	44.34	33.68	0.76	0.40	2.83	17.98	0.011							
CP	6	0.35	94.85	0.16	0.01	0.33	4.30	0.001							
	12	0.70	92.52	0.19	0.01	0.39	6.19	0.001							
	24	0.75	91.81	0.18	0.01	0.42	6.82	0.001							
	36	0.77	91.68	0.18	0.01	0.42	6.93	0.001							
	48	0.77	91.66	0.18	0.01	0.42	6.95	0.001							
EX	6	10.79	62.51	15.47	0.31	6.08	4.83	0.018							
	12	7.87	67.73	11.46	0.24	5.70	6.99	0.019							
	24	7.65	68.74	10.35	0.21	5.32	7.72	0.021							
	36	7.54	68.90	10.11	0.21	5.23	7.99	0.021							
	48	7.53	68.89	10.09	0.21	5.22	8.04	0.021							
NK	6	4.48	76.75	0.11	1.86	5.87	10.92	0.008							
	12	4.89	72.57	0.45	1.69	7.75	12.65	0.009							
	24	4.70	73.05	0.45	1.58	7.73	12.47	0.009							
	36	4.69	73.10	0.45	1.57	7.70	12.48	0.009							
	48	4.69	73.10	0.45	1.57	7.69	12.50	0.009							

## 5 The Fluctuation of World Economy and Japanese Monetary policy

In order to measure how Japanese monetary policy responds the external shocks, following Huang and Guo (2006) and NG (2002), world GDP and oil price are imposed to capture the external demand shock and supply shock. The former is used to denote world economy growth and the latter is used to denote world price level.

In this section, it firstly constructs and estimates SVAR by above two variables and the call rate of Japan.

Then considering exchange rate (Yen/US dollar) also promptly responds the external demand and supply shock, it constructs another SVAR containing four variables by adding exchange rate. Assume that world GDP and oil price are exogenous variables, and have contemporaneous effects on exchange rate and the call rate. Thus the order of variable vector is set as world GDP, oil price, exchange rate and the call rate.

The model is estimated by using monthly data from 1970:01 to 2004:06. Industrial production index of industrial countries (world IP) is used to denote world GDP. Oil price is extracted from NEEDS and the others are extracted from IFS database. Except for the call rate, all series are season adjusted, in logarithm and multiplied by 100.

Table 8 Unit root test

Variable	Level(Trend and Intercept)		First Dif.(Intercept)	
	ADF	DF-GLS	ADF	DF-GLS
World IP	-3.44(3)*	-2.80(3)*	-7.79(2)***	-2.27(5)**
Oil Price	-2.47(1)	-1.47(1)	-10.78(0)***	-10.77(0)***
Exchange Rate	-2.35(1)	-2.30(1)	-14.69(0)***	-16.64(0)***
Call Rate	-3.39(3)*	-3.24(3)**	-7.62(2)***	-3.41(5)***
Critical Values				
1% (***)	-3.98	-3.48	-3.45	-2.57
5% (**)	-3.42	-2.89	-2.87	-1.94
10% (*)	-3.12	-2.57	-2.57	-1.62

Note: This table reports the unit root test statistics (ADF and DF-GLS). The null hypothesis is that the series has a unit root. “\*”, “\*\*” and “\*\*\*” denote reject null hypothesis at 10, 5 and 1 percent level respectively. The lag lengths, shown in the parentheses, are chosen based on SIC (Schwarz Information Criterion).

Table 9 Johansen cointegration test

Variables	Lags	4	6	8	10	12	14	Critical Values (5%)
3	Trace Test	28.98	28.49	*29.84	*32.06	27.13	26.06	29.80
	M-E Test	*21.25	*21.21	20.31	*22.87	17.35	18.27	21.13
4	Trace Test	42.00	40.96	42.22	43.88	38.91	39.38	47.86
	M-E Test	25.97	26.25	23.21	25.38	19.65	19.72	27.58

Note: This table reports the statistics of trace test and maximum eigenvalue (M-E) test. “\*” denotes rejection of the hypothesis of no cointegration at the 5% level.

Before estimating SVAR models, unit root test and cointegration test are implemented to check the stability of series and cointegration among series. As reported in Table 8, level of world IP and call rate reject the hypothesis of existing a unit root at 10% level, but oil price and exchange rate can not at any level. First differences of all series reject the null hypothesis at 5 or 1 percent level. Table 9 indicates that the null hypothesis of no cointegration can't be completely rejected for 3-variable, but no cointegration exists for 4-variables at 5 percent level. Thus, the first differences of series are used to estimate the SVAR models. The length of lag is decided to 3 and 5, for 3-variable and 4-variable SVAR respectively, by final prediction error (FPE) and Akaike information criterion (AIC).

Figure 10 Impulse response functions of 3-variable SVAR

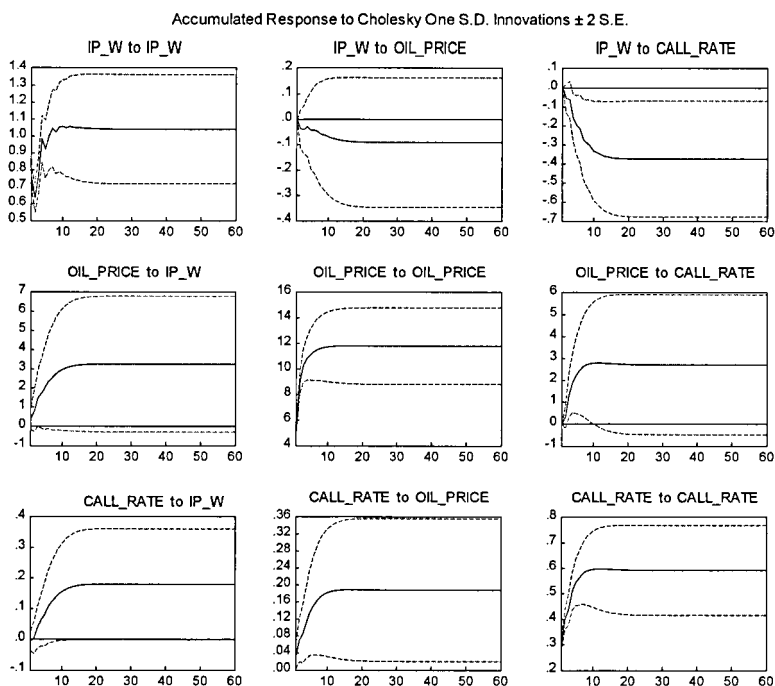
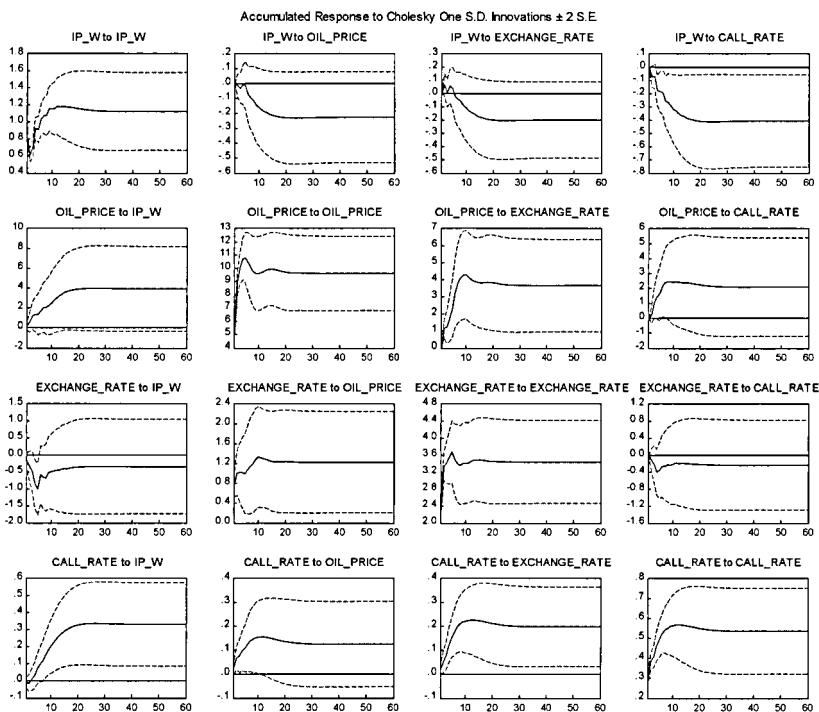


Figure 11 Impulse response functions of 4-variables SVAR



Note: The impulse response function is calculated by Monte Carlo technology with the number of replications as 500. The solid line and the dashed line represent point estimates and the standard errors band of estimated impulse responses, respectively.

Figure 10 shows the accumulated response functions obtained from 3-variable SVAR model. The last column exhibits the accumulated responses of the call rate of Japan to external demand shock and supply shock. After a unit positive shock of world IP at 0<sup>th</sup> period, the call rate of Japan jumps from 1<sup>st</sup> period and stops at about 0.18 from 15<sup>th</sup> period. It means that the Bank of Japan implement a constrictive monetary policy to respond the positive shock of world economy growth. When a unit positive shock of oil price occurs at 0<sup>th</sup> period, the call rate also jumps from 1<sup>st</sup> period and stops at about 0.18 from 9<sup>th</sup> period. Because rise of oil price raises production's cost and domestic price level. In order to restrain domestic inflation, the central bank will implement a constrictive monetary policy. These results are similar to above studies about the effects of monetary policy and domestic economic fluctuation.

Although Johansen cointegration test of 3-variable model does not support the null hypothesis of no cointegration, it also can not completely reject that. In order to check the validity of the results from 3-variable model, 4-variable SVAR without cointegration relation is estimated. The impulse response functions are reported in Figure 11. The third and forth columns represent the responses of exchange rate and the call rate to shocks, respectively. Following a unit positive shock of world IP, exchange rate declines until 5<sup>th</sup> period and comes back to -0.34 at 22<sup>nd</sup> period, the call rate jumps immediately and keeps 0.33 from 20<sup>th</sup> period. To respond a unit positive shock of oil price, exchange rate jumps to 1.24 and keeps up it from 15<sup>th</sup> period, the call rate rises and keeps up 0.13 from 23<sup>rd</sup> period.

Because Japan is one of the most important industrial countries, the rise of world GDP contains the rise of Japanese GDP. Thus, it is not surprise that the rise of world economy brings appreciation of Yen (here, it means that the value becomes small). On the other hand, as described before, the shock of world IP has positive effect on the call rate. The rise of interest rate may also become the reason of appreciating Yen. This view can also be supported by the graph of the impulse response function of exchange rate to the call rate shock (the last one in the third column). The results about the call rate in this case are similar to that from 3-variable model, though there are small differences between two cases.

## 6 Conclusion

In this paper, two empirical studies are achieved by implementing SVAR approach. One is to measure the effects of monetary policy shocks and exchange rate shock on domestic macroeconomic variables and the other is to measure how Japanese interest rate policy responds to the external demand and supply shock.

In the first study, SVAR model is constructed by seven Japanese macroeconomic variables and estimated with full sample and three sub-samples. The full sample study represents the following evidences: (1) the call rate shock and money supply shock have significant effects on economic variables; (2) the effect of shock in the credit from central bank is very small; (3) the exchange rate shock has only a limited effect on economic variables; and (4) the Bank of Japan conducts monetary policy with attaching importance to both of the call rate and money supply. The effects of shocks are changeless even if credit from central bank is imported into models, so R-model is equivalent to R-CR-model and R-M2-model is equivalent to R-M2-CR-model too. Because no "price puzzle" appears in R-M2-model, it is better to fit full sample data than R-model.

The results of sub-sample studies can be summarized as follows. In the 1970s and the early of the 1980s, although the Bank of Japan controlled bank's borrowing and lending to conduct monetary policy<sup>22</sup>, the effect of the call rate shock is obviously large. In other words, in this period the Bank of Japan treats interest rate policy as primary policy instrument. In the third sub-sample period, the call rate shock also holds significant impact on economic variables. Although the using of interest rate policy is limited since the discount rate is lowered to 0.5% in 1995, Japanese monetary policy can affect economy by controlling both of interest rate and money supply. In all three sub-sample periods, no evidence can prove that the credit from central bank or exchange rate holds large impact on economy. Similar to those in full sample, the effects of interest rate shock and money supply shock are significative, the effect of the shock in credit from central bank is very small, and the effect of exchange rate shock is limited and has no obvious variety as changing the sample period.

The results of the second study can be summarized as follows. The external demand shock has negative effect on exchange rate and positive effects on interest rate. The external supply shock has positive effects on both of exchange rate and interest rate.

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<sup>22</sup> See Kasa and Popper (1997)



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