Identification of Japanese Monetary Policy Stance with Structural VAR Models

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Abstract

This paper investigates the validity of the policy stance of the Bank of Japan. Empirical analysis is performed utilizing structural vector autoregression methodology. In particular, the proprieties of the "interest rate targeting policy" and the "reserve targeting policy" are examined with two different identifying restrictions constructed for each policy scheme. With respect to the former policy stance, impulse responses show that the shocks to the short term interest rate have reasonable effects. On the other hand, impulse responses to measure the effects of the latter policy stance show that shocks to the bank reserves are followed by appropriate responses. On the whole, policy stances by the Bank of Japan from the 1990s are basically valid.

Key words: monetary policy, policy stance, operating procedure, operating variable,
structural vector autoregression
JEL Classification: E52, E58, C32

1. Introduction

Since the positive research by Sims (1980), structural VAR (vector autoregression) has widely been applied to measure the effect of monetary policy. Bernake and Blinder (1992) and Sims (1992) stress on the role of short-term market rate as the important factor of monetary policy with the recursive frameworks of identification. Blanchard and Watson (1986), Gali (1992), Gordon and Leeper (1994), and Lastrapes and Selgin (1995) are the applications of the non-recursive approach to impose contemporaneous restriction for identification.

Bernanke and Mihov (1998) adopt the block-recursive approach to identify the shocks to monetary policy. In addition, we can find some studies to investigate the characteristics of the Japanese monetary policy applying structural VAR model. Kim (1999) deals with the G-7 countries including Japan with non-recursive identification strategy. Also, Chinn and Dooley (1998), Shioji (2000), and Bayoumi (2001) investigate the feature of monetary policy in Japan utilizing their particular identification frameworks. Kasa and Popper (1997) examine the validity of the Bank of Japan's four possible operating targets, and find some supports of the one constructed as a weighted average of the short-term interest target and non-borrowed reserves target. Mihira and Sugihara (2000) find that the monetary policy in Japan was more expansionary than usual in the late 1980s and tighter in most of 1990s. Miyao (2002) finds a persistent effect of monetary policy on real output by a simple recursive approach. Nakashima (2006) identifies the exogenous components of monetary policy by two kinds of equilibrium model of the reserve market. Particularly, the above works of Kasa and Popper (1997), Mihira and Sugihara (2000), Miyao (2002), and Nakashima (2006) are evaluated in that they put the institutional characteristics of the Bank of Japan's operating procedure to their identification strategies for the monetary policy stance. There have been various debates over the operating target and the policy stance of the central bank to have an effective transmission mechanism of monetary policy. In this sense, these researches utilizing structural VAR models offer a significant orbit of the monetary policy study.

Japanese economy was faced with the prolonged recession due to the downward revision of expected economic growth, balance sheet adjustment, and malfunction of the intermediary system derived by the non-performing asset problem since the middle of 1990s. Considering this situation, the Bank of Japan implemented the two sorts of very untraditional monetary policies to cope with the stagnant economy. One of them was the so-called "zero interest rate policy" (1999:2-2000:8), and the other one was the so-called "quantitative easing policy" (2001:3-2006:3). The Bank of Japan conducted the "zero interest rate policy" by guiding the uncollateralized overnight call rate (short-term interbank market rate) to very close to zero percent, while it implemented the "quantitative easing policy" by guiding the level of outstanding balance of the private financial institutions' current reserve account (held at the Bank of Japan). In the former case, the operating variable (or operating target) of the Bank of Japan was uncollateralized overnight call rate, and this way is the same as traditional operating procedure except the fact that the level was kept extremely low. In the latter case, however, the operating variable was temporarily the outstanding balance of the current reserve account. To put it another way, the Bank of Japan tentatively replaced its operating variable with the bank reserves, but it restored the call rate to the operating variable again at the termination of the "quantitative easing policy." It is a common view to regard the call rate as the central policy instrument of the Bank of Japan (except the special case): for instance, Okina (1993) and Ueda (1993) give overviews of the operating procedure implemented by the Bank of Japan, and both of them acknowledge that the operating target is just the call rate. Taking these arguments into account, traditional or usual policy stance of the Bank of Japan

can be regarded as a kind of "interest rate targeting policy," while the "quantitative easing policy" is a kind of "reserve targeting policy."

In this paper, we investigate the policy stance by the Bank of Japan in consideration of the validity of the "interest rate targeting policy" and the "reserve targeting policy" after the "Plaza Accord" held in 1985 by applying structural VAR methodology. The reminder of this paper is organized as follows. Section 2 highlights the characteristics of the structural vector autoregression model. Section 3 is for the empirical study by the structural VAR. Section 4 concludes.

2. Structural VAR Specification

The basic framework of the structural VAR model is as follows. Let x_t be an $n \times 1$ generic vector of endogenous variables, and u_t be an $n \times 1$ vector of structural innovation with zero mean. The pth order structural VAR model is described as:

$$
\begin{aligned}
Ax_t &= A_1^* x_{t-1} + A_2^* x_{t-2} + \cdots + A_p^* x_{t-p} + B\varepsilon_t \\
&= \sum_{i=1}^{p} A_i^* x_{t-i} + B\varepsilon_t.
\end{aligned}
\tag{1}
$$

For simplicity, constant terms are ignored here. Matrix A summarises the contemporaneous relationship among the variables, and it is usually where identification restrictions are imposed. Structural shocks are properly identified from the error terms of the estimated reduced form through the appropriate identifying restriction. Non-zero off-diagonal elements of B allow some shocks to directly affect more than one endogenous variable in the system. ε_t is a vector of structural disturbances assumed to follow white-noise processes. Their linear combinations are assumed to be white-noise processes with zero means and constant variances, and are serially uncorrelated individually. Although it is usual to restrict the variance-covariance matrix of ε_t's to be diagonal, it is not an innocuous pattern as it affects the interpretation of restrictions on matrix A.

If the variables in the right-hand side of equation (1) are correlated with the disturbance error terms, the estimation cannot be conducted by the OLS. The reduced form (corresponding to the structural form) which can be estimated utilizing a conventional OLS is obtained by premultiplying with A^{-1} provided that A is non-singular:

$$
x_t = A_1 x_{t-1} + A_2 x_{t-2} + \cdots + A_p x_{t-p} + u_t , \tag{2}
$$

where $A_j = A^{-1} A_j^*$.

$u_t = A^{-1} B\varepsilon_t$ (or $Au_t = B\varepsilon_t$) describes the relation between the reduced form disturbances (u_t) and the underlying structural shocks (ε_t). Further, we get

$$
E(u_t \ u_t') = A^{-1} BE(\varepsilon_t \ \varepsilon_t')B'A^{-1} \tag{3}
$$

and $\hat{\Sigma} = \hat{A}^{-1} B I \hat{B}' \hat{A}^{-1}.$ \tag{4}

$\hat{\Sigma}$ contains $\frac{n(n+1)}{2}$ different elements, so $\frac{n(n+1)}{2}$ is the maximum number of identifiable parameters in matrices A and B. In short, a necessary condition for identification is that the maximum number of parameters of A and B should be equal to $\frac{n(n+1)}{2}$. In other words, the number of equations should equal the number of unknowns in equation (4). Thus, identification necessitates the imposition of some restrictions on the parameters of A and B, and we have three cases: under-identification, just-identification, and over-identification. The validity of over-identified case is examined by the statistic distributed as a χ^2 with a number of degrees of freedom equal to the numbers of over-identifying restrictions.

In practice, there are four most popular ways of restriction, (a) $B=I_n$, (b) $A=I_n$, (c) $Au_t = B\varepsilon_t$ (AB-model of Amisano and Giannini (1997)), and (d) the one with the prior information on the long-run effects of some shocks like Blanchard and Quah (1986).

The properties of structural VAR are described via impulse response function after the identification of structural shocks. The effects of shocks to the variables of a given system are seen in its Wold MA (moving average) representation if the process x_t is I(0):

$$x_t = \Phi_0 u_t + \Phi_1 u_{t-1} + \Phi_2 u_{t-2} + \cdots, \qquad (5)$$

where $\Phi_0 = I_n$, and the

$$\Phi_s = \sum_{j=1}^{s} \Phi_{s-j} A_j, \ s=0,1,2,\cdots. \qquad (6)$$

It is able to be calculated recursively from the reduced form of coefficients of the VAR specified in equation (2). The coefficients of above representation are interpreted as the reflections of the responses to impulses hitting the system. The (i,j)th elements of the matrices Φ_s trace out the expected response of $x_{i,t+s}$ to a unit change in x_{it} setting all past values of x_t constant. The change in x_{it} is measured by the innovation u_{it}, so the elements of Φ_s represent the impulse response of the components of x_t to the innovations of u_t. The accumulated responses over all periods are described by

$$\Phi = \sum_{s=0}^{\infty} \Phi_s = (I_n - A_1 - A_2 - \cdots - A_p)^{-1}. \quad (7)$$

If the components of u_t are instantaneously correlated, the underlying shocks do not occur individually. Hence, orthogonalized impulse responses are preferred. There are some ways to derive them including a Choleski decomposition of the variance-covariance matrix Σ_u with a lower triangular matrix A. In the case of Choleski decomposition, matrix A should be a lower triangular such that $\Sigma_u = BB'$ and the orthogonalized shocks are obtained by $\varepsilon_t = B^{-1}u_t$. Therefore, we have following form of (5):

$$x_t = \Psi_0 \varepsilon_t + \Psi_1 \varepsilon_{t-1} + \cdots, \qquad (8)$$

where $\Psi_i = \Phi_i B, \ (i=0,1,2,\cdots)$.

However, this approach cannot be applied if A is not a lower triangular matrix. On the other

hand, In the AB-model mentioned above, the relation to the reduced form residuals is expressed as $Au_t = B\varepsilon_t$. In this case, the impulse responses in a structural VAR may be given by (8) with $\Psi_j = \Phi_j A^{-1} B$. Moreover, if we have a long-run restriction, they may be set as $\Psi = \Phi A^{-1} B$ where Φ is the matrix specified in equation (7). Therefore, the appropriate model should be chosen based on the particular frameworks and the purpose of the study.

3. Empirical Study

3.1. Model Structure

Consider the simple AD-AS type model as follows:

$$Y = Y^d(R) + \varepsilon_{IS,Y}$$
$$M = M^d(Y,R,P) + \varepsilon_{LM,M}$$
$$Y = Y^s(P) + \varepsilon_{AS,y}$$
$$P = P^s(Y) + \varepsilon_{AS,P}$$
$$R = R^p(Y,P) + \varepsilon_{MP,R}$$

where Y: production, M: money stock, P: price level, R: interest rate.

We have the basic structural VAR specification (as a dynamic model) based on the structure of this AD-AS model (as a static model). The contemporaneous relationship among the variables is reflected in the coefficient matrix (A) in the left-hand side of the following equation. A shock to each variable is described by ε. For instance, $\varepsilon_{MP,Rt}$ is defined as a "monetary shock."

$$
\begin{bmatrix}
1 & 0 & a_{YR} & 0 \\
-a_{PY} & 1 & 0 & 0 \\
-a_{RY} & -a_{RP} & 1 & 0 \\
-a_{MY} & -a_{MP} & a_{MR} & 1
\end{bmatrix}
\begin{bmatrix}
Y_t \\
P_t \\
R_t \\
M_t
\end{bmatrix}
= c + A(L)
\begin{bmatrix}
Y_t \\
P_t \\
R_t \\
M_t
\end{bmatrix}
+
\begin{bmatrix}
\varepsilon_{IS,Yt} \\
\varepsilon_{LM,Mt} \\
\varepsilon_{AS,Pt} \\
\varepsilon_{MP,Rt}
\end{bmatrix}
$$

As mentioned in section 1, there are two possible operating variables for the operating procedure of the Bank of Japan — short-term interbank market rate and bank reserves. Two models for estimation — Type I and Type II — are proposed below to consider this problem.

It is a commonly accepted view that the operating variable of the Bank of Japan is uncollateralized overnight call rate (short-term interbank market rate) except in the period of the "quantitative easing policy." However, it does not mean that the Bank of Japan ignores the other variables related to the policy decision when it conducts the operating procedure. Although the appropriate guidance of the short-term money market rate through market operations is the main concern of the central bank in the short run, stabilization of money supply or monetary base (high-powered money) is one of the intermediate targets to achieve the goal of monetary policy: price-level stabilization. Further, as Shioji (2000) suggested, if the monetary authority does not fully accommodate the demand for reserve or monetary base

immediately, policy reaction curve is not always horizontal. Therefore, the central bank may not perfectly adjust the short-term interest rate to the target level on the spot because of the care to avoid abrupt fluctuation in reserve or monetary base. This consideration implies that the slope of the supply curve of monetary base could be positive in the M-R plane. To put it another way, the slope of supply curve might be a reflection of the relative weights between interest rate and money if we consider the policy reaction function of the Bank of Japan. In this respect, empirical study to investigate the validity of the operating procedure utilizing structural VAR with a proper identification strategy is worth implementing. In addition, our model contains the stock price as an indicator of asset price since it can be the important factor of asset price route of monetary transmission. Taking these discussions into account, Type I model (interest rate targeting model) is proposed as the reflection of the discussion in this section and as the modified version of Mihira and Sugihara (2000).

Type I Model (interest rate targeting model)

$$Y = Y^d (R) + \varepsilon_{IS,Y} \qquad \text{[Y:IS]}$$

$$P = P^s (Y) + \varepsilon_{AS,P} (Y = Y^s (P) + \varepsilon_{AS,Y}) \qquad \text{[P:AS]}$$

$$R = R^p (Y,P,V) + \varepsilon_{MP,R} \qquad \text{[R:MP]}$$

$$M = M^d (Y,P,R) + \varepsilon_{LM,M} \qquad \text{[M:LM]}$$

$$V = V^d (R,M) + \varepsilon_{RD,V} \qquad \text{[V:RD]}$$

$$S = S (Y,P,R,M,V) + \varepsilon_{AP,S} \qquad \text{[S:AP]}$$

where : Y: production, P: price level, R: interest rate, M: money stock,
V: bank reserves, S: stock price, RD: demand for bank reserves,
MP: monetary policy (or policy reaction), AP: asset price.

$$
\begin{bmatrix}
1 & 0 & a_{YR} & 0 & 0 & 0 \\
-a_{PY} & 1 & 0 & 0 & 0 & 0 \\
-a_{RY} & -a_{RP} & 1 & 0 & -a_{RV} & 0 \\
-a_{MY} & -a_{MP} & a_{MR} & 1 & 0 & 0 \\
0 & 0 & a_{VR} & -a_{VM} & 1 & 0 \\
a_{SY} & -a_{SP} & -a_{SR} & a_{SM} & a_{SV} & 1
\end{bmatrix}
\begin{bmatrix}
Y_t \\ P_t \\ R_t \\ M_t \\ V_t \\ S_t
\end{bmatrix}
= c + A(L)
\begin{bmatrix}
Y_t \\ P_t \\ R_t \\ M_t \\ V_t \\ S_t
\end{bmatrix}
+
\begin{bmatrix}
\varepsilon_{IS,Yt} \\ \varepsilon_{AS,Pt} \\ \varepsilon_{MP,Rt} \\ \varepsilon_{LM,Mt} \\ \varepsilon_{RD,Vt} \\ \varepsilon_{AP,St}
\end{bmatrix}
$$

This is the case of just-identification restriction. The coefficient matrix in the left-hand of the above equation summarises the contemporaneous relationship among the variables. In this case, shocks to R are regarded as the indicator of exogenous monetary policy shocks, and the third row of matrix A expresses the assumption that coefficient a_{RV} is set as the weight for the reduced form innovations in interest rate (u_{Rt}) and in bank reserves (u_{Vt}) for the structural shocks to monetary policy ($\varepsilon_{MP,Rt}$). The fifth row of matrix A indicates that the structural shocks to V ($\varepsilon_{RD,Vt}$) is assumed to be related to the reduced form innovation in interest rate (u_{Rt}) and that in monetary base (u_{Mt}). This specification can be regarded as a kind of nested model since we are able to indirectly examine the propriety of interest rate targeting by

examining whether the estimated coefficient of a_{RV} is close to zero. Y and P are placed before the monetary instrument in this model because of the assumption that the monetary authority acknowledges current Y and P when it decides the level of monetary instrument and that Y and P respond to a policy shock with a lag. Since financial markets are assumed to respond to a policy shock without any lags, S is placed at the end of the line.

As we have already known, during the period of the "quantitative easing policy" in the early 2000s, the operating variable of the Bank of Japan was tentatively the quantity of current account balances of the bank reserves which is held at the Bank of Japan. To implement the estimation so that we can measure the effect of this kind of reserve targeting, Type Ⅱ structural VAR specification is proposed as the reflection of the discussion in this section and as the modified version of Mihira and Sugihara (2000).

Type Ⅱ Model (reserve targeting model)

$$Y = Y^d(R) + \varepsilon_{IS,Y} \qquad [Y:IS]$$
$$P = P^s(Y) + \varepsilon_{AS,P}(Y = Y^s(P) + \varepsilon_{AS,Y}) \qquad [P:AS]$$
$$R = R^d(M,V) + \varepsilon_{RD,R} \qquad [R:RD]$$
$$M = M^d(Y,P,R) + \varepsilon_{LM,M} \qquad [M:LM]$$
$$V = V^P(Y,P) + \varepsilon_{MP,V} \qquad [V:MP]$$
$$S = S(Y,P,R,M,V) + \varepsilon_{SP,S} \qquad [S:AP]$$

$$
\begin{bmatrix}
1 & 0 & a_{YR} & 0 & 0 & 0 \\
-a_{PY} & 1 & 0 & 0 & 0 & 0 \\
0 & 0 & 1 & -a_{RM} & a_{RV} & 0 \\
-a_{MY} & -a_{MP} & a_{MR} & 1 & 0 & 0 \\
a_{VY} & a_{VP} & 0 & 0 & 1 & 0 \\
a_{SY} & -a_{SP} & -a_{SR} & a_{SM} & a_{SV} & 1
\end{bmatrix}
\begin{bmatrix}
Y_t \\ P_t \\ R_t \\ M_t \\ V_t \\ S_t
\end{bmatrix}
= c + A(L)
\begin{bmatrix}
Y_t \\ P_t \\ R_t \\ M_t \\ V_t \\ S_t
\end{bmatrix}
+
\begin{bmatrix}
\varepsilon_{IS,Yt} \\ \varepsilon_{AS,Yt} \\ \varepsilon_{RD,Rt} \\ \varepsilon_{LM,Mt} \\ \varepsilon_{MP,Vt} \\ \varepsilon_{AP,St}
\end{bmatrix}
$$

This is the case of over-identification restriction. In this model, shocks to V are regarded as the indicator of exogenous monetary policy shocks. Moreover, the third row of matrix A expresses the assumption that the structural shocks to R ($\varepsilon_{RD,Rt}$) is related to the reduced form innovation in monetary base (u_{Mt}) and that in bank reserves (u_{Vt}), while the fifth row indicates that the structural shocks in V ($\varepsilon_{MP,Vt}$) is assumed to be related to the reduced form innovation in output (u_{Yt}) and that in price level (u_{Pt}).

3.2. Estimation Results

This section is for the empirical study utilizing the structural VAR with the two types of identification strategies described in the previous section. The AB-model of Amisano and Giannini (1997) is applied. Matrix A is for the contemporaneous relationship among the variables and Matrix B is assumed diagonal. Monthly data are adopted to have enough number of samples. All variables except interest rate are in logarithms. Specifically, the estimation

contains the following variables.[1)]

      Y: industrial production (connected indices, value added, mining and manufacturing, seasonally adjusted; base year: 2005)

      P (for Type Ⅰ): consumer price index (all Japan, general, excluding fresh food; base year: 2005)

      P (for Type Ⅱ): consumer price index (all Japan, general, excluding fresh food, seasonally adjusted; base year: 2005)

      R: uncollateralized overnight call rate (monthly average, percent)

      M: monetary base (reserve requirement rate change adjusted, 100 million yen, seasonally adjusted)

      V: current account balances (average outstanding, 100 million yen)

      S: Nikkei Stock Average (TSE 225 Issues, yen)

With respect to the selection of consumer price index (as P), seasonally adjusted series are adopted for Type Ⅱ, while seasonally non-adjusted series are taken for Type Ⅰ, since the former series are available only from 2001:1 but the latter series are available before the start date of the sample period for the Type Ⅰ model. Two sets of sample period are offered for Type Ⅰ model: (a) the period from 1985:7 to 1999:1 and (b) the period from 1985:7 to 2000:8. The (a) is for the investigation with regard to the period from the month just before the "Plaza Accord" to the month just before the introduction of the "zero interest rate policy." The (b) is for the period from the month just before the "Plaza Accord" to the termination of the "zero interest rate policy." For Type Ⅱ, the sample period from 2001:3 to 2006:3 is offered in order to examine the effect of the "quantitative easing policy." Monetary base is contained as the narrower money stock rather than the broad monetary aggregates. As Favero (2001) suggested, it becomes easier to identify shocks which mainly driven by the behavior of the monetary policy authority if we utilize the narrower monetary aggregates rather than the broad aggregates for the estimation. In other words, monetary shock measured by broad aggregates might be a complicated mixture of various shocks in the market. Therefore, monetary base is contained in our model as the narrower monetary aggregates.

    Throughout the analyses, impulse response functions in levels, rather than the first differences, are derived following recent convention. This issue is a kind of controversial matter. However, as Bernanke and Mihov (1997) suggested, an impulse response based on a levels specification derives consistent estimates whether cointegration exists or not, although the one based on a difference specification is not consistent if it has some cointegrated variables. Estimations of the structural forms are implemented by maximum likelihood method to avoid simultaneous equations biases. Time trend is not included. Lag length is determined as two based on Hannan-Quinn information criterion setting the maximum length is six.

    Table 1 and Table 2 show the estimated coefficient matrices of A (the matrices which express the contemporaneous relationship among the variables) for the sample periods (a) and (b) respectively with the Type Ⅰ identification restriction. As described in the previous

section, Type Ⅰ is constructed as a nested model to investigate the propriety of the "interest rate targeting policy." Thus, the estimated coefficient of a_{RV} is examined. In the case of (a), the estimated coefficient of a_{RV} is 62.69431: it is positive and not significant. This estimated coefficient is not close to zero, we cannot conclude that the policy stance of the Bank of Japan in the period (a) is a pure "interest rate target policy" in this point of view. It might reflect the difficulties with regard to the operating procedure of the Bank of Japan in the period of concern mentioned in section 2. In Table 2, estimated coefficient of a_{RV} is indicated as 24.79063. Its sign is not properly given and the value is not close to zero. Thus, we are not able to have a favourable conclusion again. Nevertheless, we must take one point of reservation into account when we consider this kind of issue. As Iwabuchi (1990) points out, it is not always appropriate to regard the contemporaneous relation among the variables as worthless because of only the wrong signs and the insignificances of the estimated coefficients. Since the interdependence of the variables depends not only on the contemporaneous factors but on other various underlying elements, signs and significances of the coefficients might have chances to be incorrectly estimated in this kind of dynamic analysis. Therefore, it is often said that the innovation accounting including impulse response analysis has more significant meaning in this line of VAR literature.

With regard to the "reserve targeting policy," Table 3 is for the estimated coefficient matrix for the period of the "quantitative easing policy" based on the Type Ⅱ identification restriction. The null hypothesis for the test of over-identification cannot be rejected (The test statistics is indicated in the notes below Table 3).

Next, we consider the estimated impulse responses taking the significance of the innovation accounting described above into account. Figure 1 shows the estimated cumulative impulse responses based on Type Ⅰ model for the sample period (a). The solid line indicates the estimated response for each of the variables up to 48 months. The dotted lines represent ± two standard error bands. First, responses to the shock to R should be considered to examine the validity of the interest rate targeting policy. It is shown that the response of Y to a positive shock to R is consistent with a usual assumption － a rise in R is followed by a decline in Y. This suggests the call market rate guidance by the Bank of Japan had a proper and a persistent effect on real output in the period of concern. Next, a shock to R is followed by a small positive response of P for about 24 months. It means the so-called "price puzzle"[2] appears although it is not so large. The response of monetary base (or high-powered money) to a positive shock to R gradually declines. Therefore, our estimation is not suffered from the "liquidity puzzle."[3] The response of stock price to the shock to interest rate turns to be negative, and this result corresponds to our standard postulate. The positive response of bank reserves is the unfavorable problem here: it might be related to the complicated structure of the Bank of Japan's operating procedure with respect to the bank reserves and the call rate as described in the previous section.

Our next concern is to examine the responses to a shock to V. Shocks to V are followed by positive responses of Y, M, and S. These responses are consistent with the usual beliefs.

Table 1: Estimated Matrix A for Type Ⅰ (a)

Y	P	R	M	V	S
1.000000	0.000000	0.020433	0.000000	0.000000	0.000000
0.005465	1.000000	0.000000	0.000000	0.000000	0.000000
−33.55140	−78.31457	1.000000	0.000000	62.69431	0.000000
0.500365	9.61E−05	−0.044143	1.000000	0.000000	0.000000
0.000000	0.000000	−0.369508	−22.25510	1.000000	0.000000
0.409212	1.430107	0.027964	0.926016	−0.011224	1.000000

Notes: Structural VAR is just-identified. Included observations = 95.
Convergence achieved after 500 iterations.
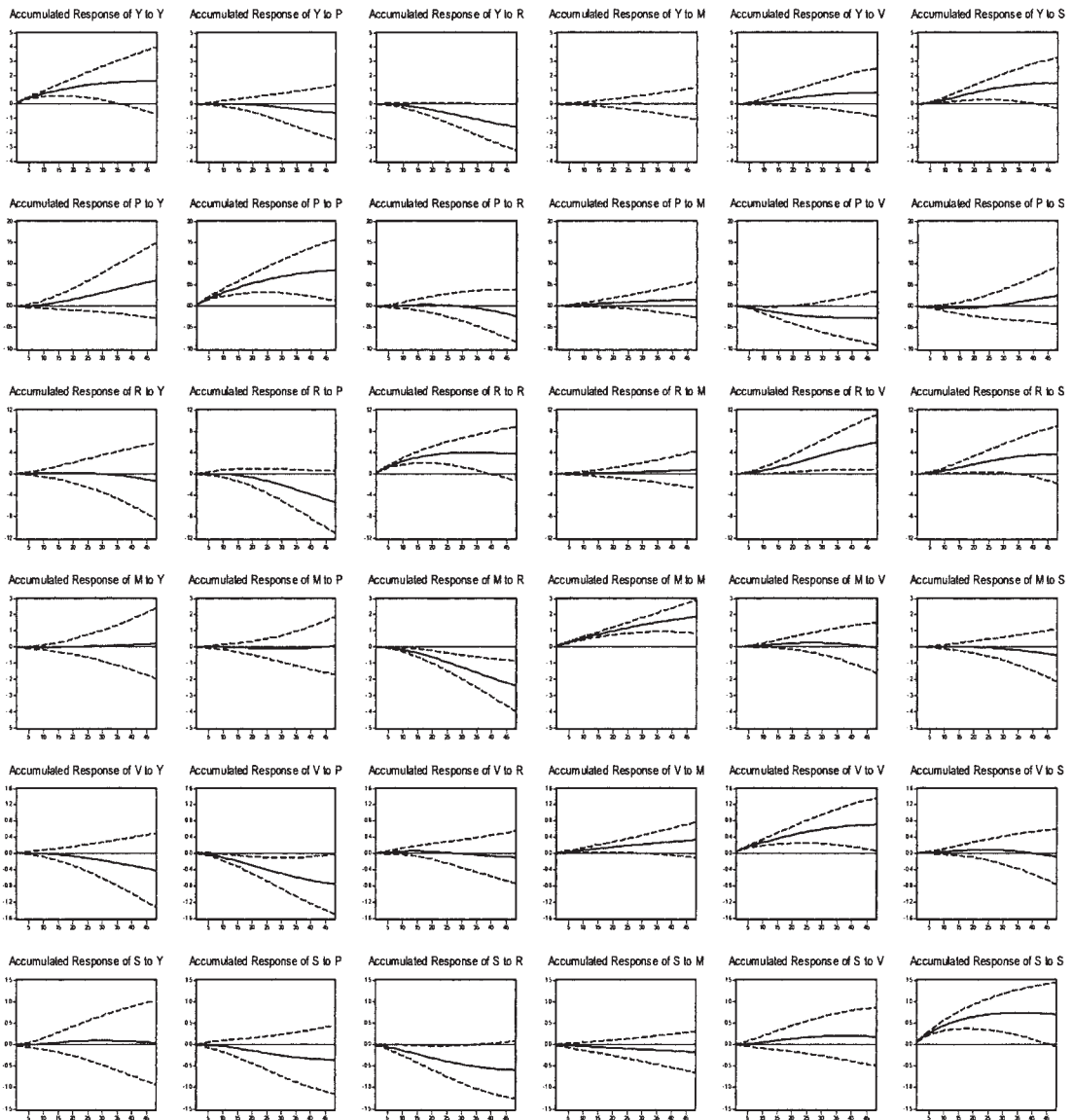
Figure 1: Accumulated Impulse Response for Type Ⅰ (a)

Table 2: Estimated Matrix A for Type Ⅰ (b)

Y	P	R	M	V	S
1.000000	0.000000	24.24449	0.000000	0.000000	0.000000
−0.022571	1.000000	0.000000	0.000000	0.000000	0.000000
−628.3935	−199.7990	1.000000	0.000000	24.79063	0.000000
0.268829	0.294655	0.001974	1.000000	0.000000	0.000000
0.000000	0.000000	−0.019440	−5.056354	1.000000	0.000000
0.336731	1.353803	0.023723	0.479051	−0.083284	1.000000

Notes: Structural VAR is just-identified. Included observations = 180.
   Convergence achieved after 113 iterations.

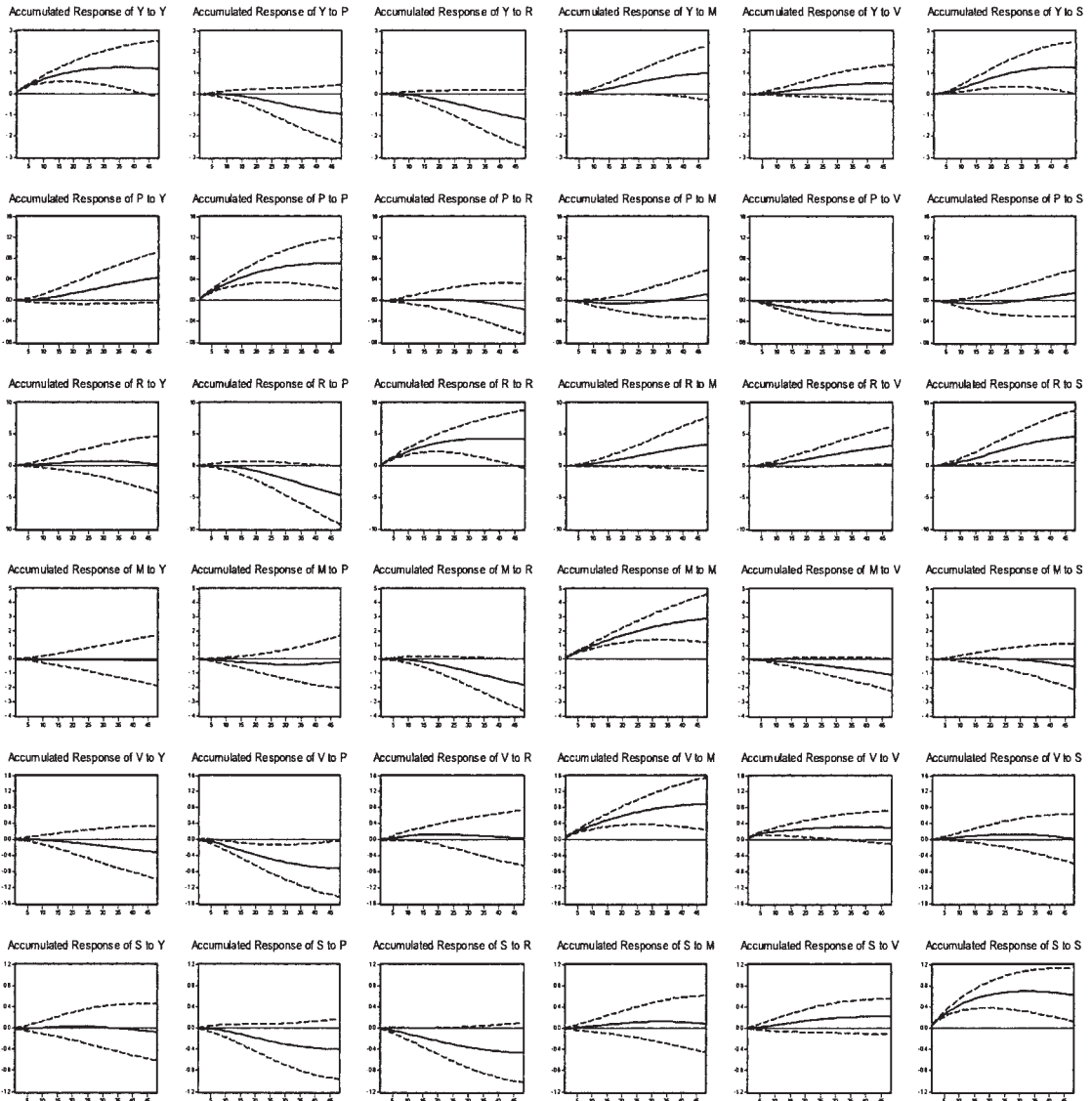Figure 2: Accumulated Impulse Response for Type Ⅰ (b)

Table 3: Estimated Matrix A for Type Ⅱ

Y	P	R	M	V	S
1.000000	0.000000	5.448438	0.000000	0.000000	0.000000
0.045849	1.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	1.000000	−1.922579	0.343421	0.000000
−3.031293	3.775819	6.613392	1.000000	0.000000	0.000000
5.526933	−19.53867	0.000000	0.000000	1.000000	0.000000
1.564678	3.742351	−0.118282	−1.014896	0.247440	1.000000

Notes: Structural VAR is over-identified. Log likelihood = 1229.631.
    LR test for over-identification = 0.707384. Included observations = 61.
    Convergence achieved after 118 iterations.

Figure 3: Accumulated Impulse Response for Type Ⅱ
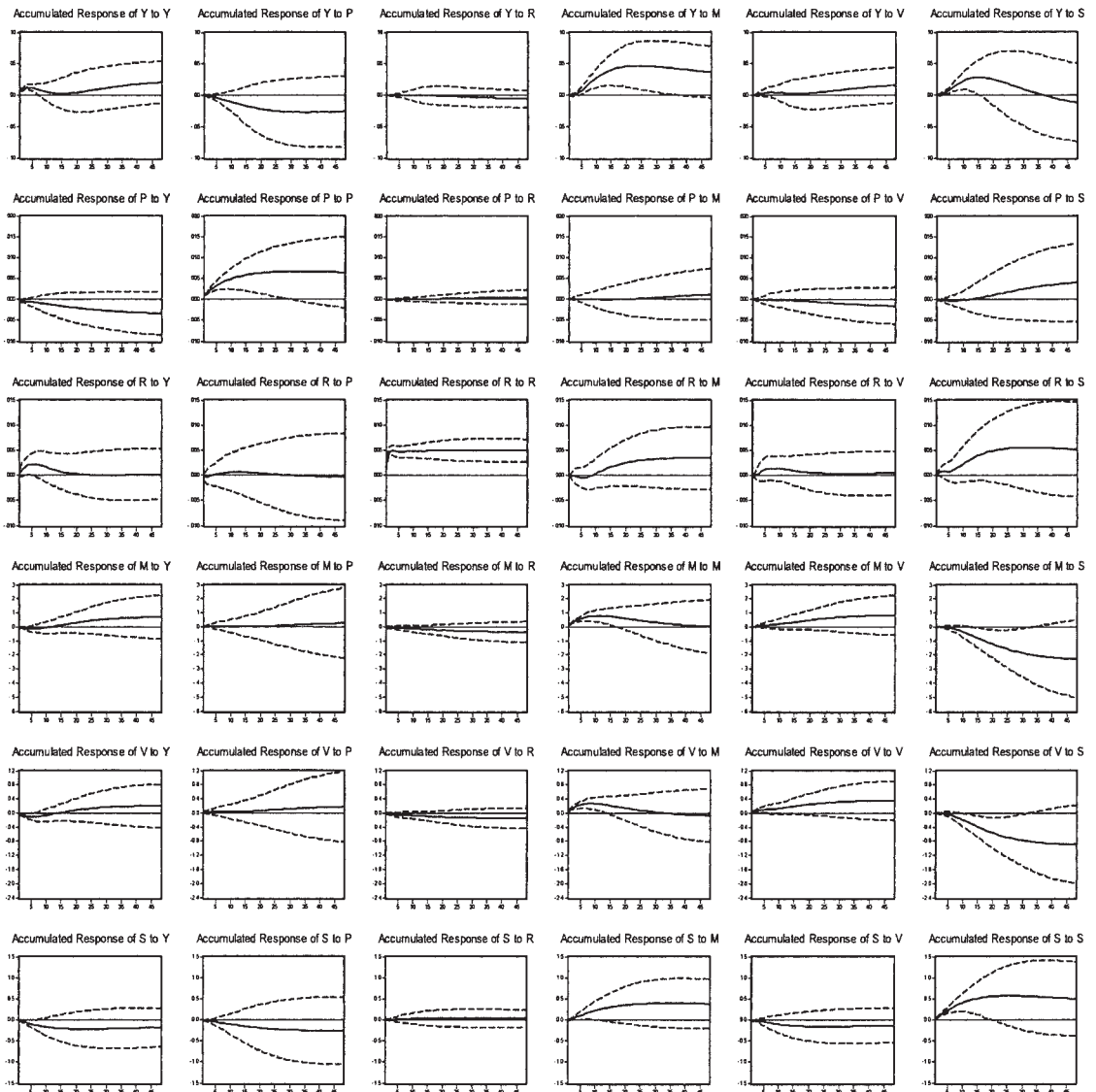
However, negative response of P and positive response of R to the shocks to V are not always reasonable. The former problem might be related to the prolonged deflationary pressure of Japanese economy, and the latter one might be related to the problem of operating procedure of the Bank of Japan.

As to a different sample period, Figure 2 represents the impulse responses based on Type Ⅰ model in the case of sample period (b). Responses basically show the same patterns of behavior as we see in the case of (a) except one point. A positive shock to V is followed by a positive response of M in the sample period (a), but by a negative response in (b). It might imply the unusual relation between the bank reserves and the monetary base after the introduction of the "zero interest rate policy."

Overall, from the viewpoint of the estimated impulse responses, the shocks to the interest rate have relatively reasonable effects on the variables compared with the one to bank reserves except the "price puzzle" problem. In this respect, the "interest rate targeting policy" by the Bank of Japan by choosing call rate as the operating variable was for the most part appropriate in the period of concern although we found some ambiguous factors.

Figure 3 reports the impulse responses for the sample period of the "quantitative easing policy" derived by the estimations with Type Ⅱ model (which is constructed to examine the validity of the "reserve targeting policy"). Shocks to V are followed by persistent positive responses of M and Y, although the response of Y fluctuates a little. In addition, the impulse response of P to a rise in V is ambiguous in the short run and negative in the long run. These responses might imply the difficulty for the Bank of Japan in dealing with the stagnant economy in the early 2000s. Response of R and S are inconsistent with the usual assumption. On the other hand, shocks to R are barely accompanied by negative responses of V and M, but the responses of Y and P are very ambiguous. Considering these impulse responses, shocks to V are relatively more effective than the ones to R. Thus, it can be concluded that the "quantitative easing policy" as a reserve targeting policy by the Bank of Japan worked in its own way in the early 2000s although its effect was not so strong. The weakness of the policy might be related to the malfunction of the transmission mechanism of monetary policy in this period.

4．Concluding Remarks

In this paper, we investigated the propriety of the policy stance of the Bank of Japan from the "Plaza Accord" by applying structural VAR methodology. In particular, the validities of the "interest rate targeting policy" and the "reserve targeting policy" were examined with two different identifying restrictions constructed for each policy scheme. With respect to the "interest rate targeting policy," impulse responses showed that shocks to call rate had the appropriate effect on real output in the period of concern. On the other hand, impulse response analysis to investigate the effect of the "reserve targeting policy" in the period the Bank of Japan implemented the "quantitative easing policy" showed that shocks to bank reserves are followed by positive responses of monetary base and real output although they are not so

strong. The response of price level to a shock to the reserve is ambiguous in the short run and negative in the long run. This might reflect the Bank of Japan's difficulty in conducting monetary policy in the early 2000s.

On the whole, it can be concluded that the two kinds of monetary policy stance the Bank of Japan conducted — the "zero interest rate policy" (as the "interest rate targeting policy") and the "quantitative easing policy" (as the "reserve targeting policy") — were respectively valid from the result of this study although we found some difficulties.

Since the empirical analysis in this study has some unclear elements, we are not able to regard the result here as definite. A natural extension of this work is required.

Notes

1) The industrial production is retrieved from the Ministry of Economy, Trade and Industry's home on the world wide web (http://www.meti.go.jp/english/). The consumer price index is retrieved from the Ministry of International Affairs and Communications, Statistics Bureau, Director-General for Policy Planning (Statistical Standards) & Statistical Research and Training Institute's home on the world wide web (http://www.stat.go.jp/english/index.htm). The consumer price index is also recorded in International Financial Statistics. The monetary base, the current account balances, and the Nikkei Stock Average are retrieved from the Bank of Japan's home on the world wide web (http://www.boj.or.jp/en/index.htm).

2) See Sims (1992), Strongin (1995), and Christiano et al. (1999).

3) See Strongin (1995).

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