Article

Measuring Japanese Monetary Policy

Kiyotaka Nakashima *†

January 12, 2005

Abstract

This paper quantitatively conceptualizes the Bank of Japan (BOJ)'s policy decisions by employing Bernanke and Mihov's (1998) econometric methodology for developing monetary policy measures. The paper shows that, in the subperiod to June 1995, the call rate alone should be used as the policy indicator of the BOJ. However, in the subperiod from July 1995, an equally weighted average of the call rate and reserves should be used. Furthermore, the paper presents a useful measure of BOJ policy that identifies its past policy decisions over time, and refers to the derived policy measure as the ‘actual policy measure’.

JEL classification: C32 ; E52 ; E58

Keywords: monetary policy measure; structural vector autoregression; discount-window policy, Japanese monetary policy.

*Correspondence to: Kiyotaka Nakashima, Faculty of Economics, Kyoto Gakuen University, 1-1, Ootani, Nanjo, Sagabecho, Kameoka, Kyoto, Zip 621-8555, Japan, e-mail: nakakiyo@kkyota-gakuren.ac.jp, phone: +81-0772-29-2332, fax: +81-075-822-9014.
†This paper is based on my PhD dissertation (Chapters 2 and 3) from Osaka University, but is substantially revised. I thank Tsutomu Watanabe, Sigenori Shiratsuka, Ryuji Miyao, Etsuro Shiji, Akira Furukawa, Yoshiaki Shikano, Shingo Takagi for helpful comments and suggestions. I especially thank Yuzo Honda and Makoto Saito for valuable discussion and criticism of the previous version of this paper. Financial support from the Zenjin Foundation is gratefully acknowledged.
1 Introduction

Accurate evaluation of monetary policy requires an adequate policy indicator. Among studies of US monetary policy, Bernanke and Blinder (1992) argue that the federal funds rate has been the primary policy target of the Federal Reserve (Fed), Christiano and Eichenbaum (1999) use nonborrowed reserves as the policy indicator, and Stron- gos (1995) proposes use of that part of nonborrowed reserves growth that is orthogonal to total reserve growth.

Past studies of Japanese monetary policy have assumed that the Bank of Japan (BOJ) has always implemented policy by changing the call rate. Miyao (2000, 2002), Ogawa (1999) and Hatakeda (1997) assume that the behavior of the call rate reflects the BOJ’s policy decisions over time. However, does this assumption always apply for analysis of Japanese monetary policy? Since July 1995, the call rate has hardly changed from around zero (see Figure 1). Since March 2001, the BOJ has adopted a new policy framework, which involves expanding reserves as much as lowering the call rate. Furthermore, previous studies of the BOJ’s policy indicators to June 1995 do not necessarily support the view that only the call rate reflects the BOJ’s policy decisions. This paper attempts to conceptualize quantitatively the BOJ’s policy decisions by employing Bernanke and Mihov’s (1998) econometric methodology for developing monetary policy measures. In particular, the paper shows that, in the subperiod to June 1995, the call rate alone should be used as the policy indicator of the BOJ. However, in the subperiod from July 1995, an equally weighted average of the call rate and reserves should be used. Therefore, the paper empirically demonstrates that individual monetary variables alone cannot explain the BOJ’s past policy decisions over time. Furthermore, we present a BOJ policy indicator that is useful for the entire period from January 1980 to May 2003 by utilizing Bernanke and Mihov’s methodology. The derived indicator, termed the ‘actual policy measure’, provides an explanation of the BOJ’s historical decisions over time.

This paper is organized as follows. Section 2 determines the actual policy measure by applying the econometric methodology of Bernanke and Mihov. Section 3 discusses the plausibility of the derived policy measure with an impulse response analysis. Section 4 concludes the paper.

---

1) The narrative approach put forward by Romer and Romer (1989) tries to extract information on key policy actions taken by looking at publications of the Fed, e.g., the minutes of the policy committee or other statements of the decision-making bodies. Building on Romer’s work, Bosch and Mills (1991) rate monetary policy on a discrete scale, -2, -1, 0, 1, 2 where -2 denotes very tight and +2 denotes very loose.

2) Shioji (2000) and Nakashima (2003) explored policy indicators of the BOJ to June 1995 by using vector autoregression (VAR) methodology. Shioji, who estimated an econometric model of the Japanese high-powered money market, concluded that the call rate and quantity indicators such as M2 + CD, or high-powered money, are useful as indicators of the BOJ’s policy. On the other hand, Nakashima, who estimated an econometric model of the Japanese reserve market by using Bernanke and Mihov’s (1998) methodology, concluded that the call rate is the best indicator of BOJ policy.
2 Determining an Actual Policy Measure

Application of Bernanke and Mihov’s structural VAR methodology involves developing equilibrium econometric models of the reserve market. In particular, when modeling the Japanese reserve market, it should be noted that the introduction of a low interest rate policy in July 1995 shifted the BOJ’s discount-window policy. The section determines the actual policy measure of the BOJ by considering the shift in the discount-window policy and the institutional differences between operating procedures in Japan and in the US.

2.1 Bernanke and Mihov’s Methodology

To determine the actual policy measure of the BOJ, we follow Bernanke and Mihov in supposing that the economy is described by the linear structural model given by equations (1) and (2):

\[
Y_t = \sum_{i=0}^{k} B_i Y_{t-i} + \sum_{i=1}^{k} C_i P_{t-i} + A^p \nu^p_t
\]

\[
P_t = \sum_{i=0}^{k} D_i Y_{t-i} + \sum_{i=0}^{k} G_i P_{t-i} + A^p \nu^p_t
\]

where variables in bold type denote vectors or matrices.

Following Bernanke and Mihov, we refer to \( Y \) and \( P \) as ‘non-policy’ and ‘policy’ variables, respectively. The set of policy variables includes variables that are potentially useful as direct indicators of the stance of monetary policy, such as short-term interest rates and reserve measures. Non-policy variables include other economic variables, such as output and inflation. In equations (1) and (2), the \( \nu^p \)’s are mutually uncorrelated ‘structural’ or ‘primitive’ disturbances. In particular, one element of the \( \nu^p \) is a money supply shock or monetary policy shock, and the other elements of \( \nu^p \) may include shocks to money demand or any disturbance that affects the policy variables.

Bernanke and Mihov assumed that the non-policy variables \( Y \) depend only on lagged values of the policy variables \( (\nu = 0) \). Given the timing assumption, the system given by (1) and (2) may be rewritten in VAR form (with only lagged variables on the right-hand side) and estimated by standard methods. As in Bernanke and Mihov, let \( u^p_t \) be the parts of the VAR residuals in the policy block that are orthogonal to the VAR residuals in the non-policy block. Then Bernanke and Mihov showed that \( u^p_t \) satisfies

\[
(I - G^p) u^p_t = A^p \nu^p_t
\]

Equation (3) is a standard structural VAR system, which relates observable VAR-based innovations, \( \nu \), to unobservable structural shocks, \( \nu^p \). The Bernanke.Mihov methodology proposes identifying exogenous components of monetary policy and examining policy indicators by developing equilibrium models of the reserve market in the form of (3). To model the Japanese reserve market, we discuss the BOJ’s operating procedures in the light of its discount-window policy.

2.2 The BOJ’s Discount-Window Policy

To develop an equilibrium model of the reserve market, we must understand the central bank’s policy behavior in the reserve market; i.e., how it supplies high-powered money (reserves plus currency).

In general, central banks have two ways of controlling the supply of highpowered money. One is to engage in open-market operations and the other is to engage in discount-window lending. In particular, management of the discount window takes two forms depending on the relationship between the discount rate and short-term policy rates such as the call rate and the federal funds rate. One relates to the way in which a central bank sets the discount rate below the short-term policy rate. The other relates to the way in which it sets the short-term rate below the discount rate.

Historically, the BOJ has adopted both forms of discount-window policy. Figure 1 shows paths of the call rate and the discount rate,
which indicate that the discount rate remained below the call rate until June 1995 and has remained above it since July 1995, when the BOJ implemented a low interest rate policy. This suggests that management of the BOJ's discount window policy before June 1995 was similar to that of the Federal Reserve (Fed), because the US discount rate is persistently below the federal funds rate. However, there is an important difference. The BOJ eased (tightened) policy by increasing (reducing) discount-window borrowing quotas for private banks. Therefore, the BOJ took the initiative to control the level of discount-window lending and regulate the quantity of borrowing. As moral suasion is not used in the manner used by the Fed to reduce discount-window borrowing, private banks usually borrow their quota amounts. In the literature on Japan's monetary policy, this type of management of the BOJ's discount window is generally characterized as 'credit rationing'. On the other hand, in the literature on US monetary policy, it is supposed that borrowing from the Fed depends on private banks' decisions, and that the Fed endogenously accommodates the demand for discount-window borrowing by private banks. To model the Japanese reserve market, we must consider the difference between discount-window management in Japan and in the US.

In July 1995, the BOJ, by setting the discount rate above the call rate, converted the discount rate into a penalty rate. The penalty rate eliminates the need for rationing at the discount window, and private banks usually have no incentive to borrow from the BOJ. Therefore, the BOJ's discount window accommodates demand shocks for discount-window borrowing provided systemic risk in the short-term money market makes it difficult for private banks to finance in this market.

Given the history of the BOJ's discount-window policy, we must develop two equilibrium models of the Japanese reserve market, for before and after June 1995. In the following subsections, we present two equilibrium models of the Japanese reserve market. One is the Credit Rationing (CR) model, relevant to June 1995, and the other is the Low Interest Rate (LIR) model, applicable from July 1995.

2.3 Before June 1995 - CR (Credit Rationing) Model

The following system, (4)-(9), describes the Credit Rationing (CR) model.

\[ u^{re} = u^{re} + u^{mo} - u^{dd} - u^c \]
\[ u^{dd} = \theta^d + v^d \]
\[ u^c = -\alpha u^r + v^c \]
\[ u^s = -\beta u^r + v^s \]
\[ u^{re} = \theta^{re} + \theta^{rr} u^{re} + \theta^{dd} u^{dd} + \theta^{v^s} + v^s \]
\[ u^{mo} = \theta^{dd} u^{dd} + \theta^{ru} u^{ru} + \theta^{dd} u^{dd} + \theta^{v^s} + v^s \]

where \( gd, cu, re, br, \) and \( mo \) denote government deposits, currency, reserves, borrowed reserves, and assets held through open-market operations by the BOJ, respectively, and \( r \) denotes the call rate.

Equation (4) is the market-equilibrium condition for bank reserves, which is based on an identity between assets and liabilities on the BOJ's balance sheet (see Table 1). Equation (5) implies that the BOJ

3) Hamada and Iwata (1980) and Honda (1984) each developed theoretical models of the credit rationing view, and the former used empirical analysis to support their view. Furthermore, Ueda (1993) stated: “The discount rate has always been lower than the call rate. Therefore, discount-window lending has been rationed in Japan. And the level of lending has been changed by the BOJ, not by private banks” (p. 12, lines 17-19).

4) The type of discount-window policy pursued by the US is generally referred to as the ‘implicit cost regime’ in the literature on Japan’s monetary policy.

5) It is interesting that, unlike the Fed, the BOJ has not used the concept of nonborrowed reserves. This is a major difference between the operating procedures of the BOJ and those of the Fed. Bernanke and Mishkin’s econometric model of the US reserve market incorporates an equilibrium condition for total reserves (member-bank deposits + vault cash) = borrowed reserves + nonborrowed reserves. Kasa and Popper (1997) have already applied the Bernanke-Mishkin methodology to Japanese
accommodates fluctuations in the demand for government funds, \( v^{nd} \). Equation (6) relates innovations in the demand for currency, \( u^c \), to innovations in the call rate, \( u' \), and an autonomous shock to currency demand, \( v^c \). Similarly, equation (7) represents the banks’ demand for reserves, expressed in the form of innovations: it states that innovations in the demand for reserves, \( u^r \), depend negatively on innovations in the call rate, \( u' \), and on a demand disturbance, \( v^d \).

Equation (8) represents the distinguishing feature of the CR model. It shows that the BOJ controls the level of discount-window lending and rations lending to private banks. Hence, we interpret this equation as a behavior function for the BOJ. In particular, \( v^b \) represents the supply shock for discount-window lending and is defined as a policy shock. Equation (9) is the second behavior function in the CR model, and shows how the BOJ supplies high-powered money using open-market operations. In particular, \( u^m \) represents the high-powered money supply shock from using open-market operations and can be considered as the second monetary policy shock, with \( v^b \) in equation (8) being the first.

The CR model implies that the BOJ affects the short-term money market and the macroeconomy through both open-market operations and discount-window lending, because the model has two BOJ behavior functions. Furthermore, the two behavior functions are essentially equivalent because they are both high-powered money supply functions of the BOJ. Therefore, in the CR model, it is the quantity, rather than the composition, of high-powered money that matters. Hence, adding equations (8) and (9) yields the following system, which is essentially equivalent to the CR model.

\[
\begin{align*}
    u^c &= u^{ol} - u^m - u^a \\
    v^d &= v^p^d \\
    u^m &= -\alpha u^r + v^{su} \\
    u^r &= -\beta u^r + v^d \\
    u^{md} &= q^{p} v^d + q^{sp} u^r + q^{s} v^d + v^{md} \\
\end{align*}
\]

In this context, the VAR innovation, \( u^{md} \), is defined as follows:

\[ u^{md} = u^r + u^{mo} \]

The above system can be represented in the form of equation (3) as follows:

\[
I - G_0 = \begin{bmatrix}
1 & 0 & 0 & 0 \\
0 & 1 & \alpha & 0 \\
-1 & -1 & \beta & 0 \\
0 & 0 & 0 & 1
\end{bmatrix}, \quad A_0 = \begin{bmatrix}
1 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 \\
0 & 0 & 1 & 0 \\
q^{p} & q^{sp} & q^{s} & 1
\end{bmatrix}
\]

\[ u' = [u^d \ u^m \ u^r \ u^{md}], \quad v' = [v^p^d \ v^{su} \ v^d \ v^{md}] \]

Inverting the above relationship reveals how the monetary policy

---

6) Equation (8) indicates another major difference between the operating procedures of the BOJ and those of the Fed. In the literature on US monetary policy, it is supposed that private banks are reluctant to borrow from the discount window because of various sanctions and restrictions imposed by the Fed on banks’ use of the window. Hence, the Fed only accommodates demand for discount-window borrowing by private banks. Specifically, Bernanke and Mihov used a conventional borrowing function, in which borrowing depends positively on the spread between the funds rate and the discount rate. Using data to June 1995, Nakashima (2003) found strong evidence against a model of the Japanese reserve market that incorporates a US-type borrowing function rather than one of the form of equation (8).
shock, \( v^{nd} \), depends on the VAR innovations:

\[
\begin{align*}
v^{nd} &= -(\alpha \psi^{cm} + \beta \psi^{e}) u^{e} + (1 - \psi^{e}) u^{re} \\
&
+ (1 - \psi^{cm}) u^{cm} + (1 - \psi^{re}) u^{rd}
\end{align*}
\]  

(11)

The CR model described by the above system has nine unknown parameters (including the variances of four structural shocks) to be estimated from 10 covariances. Hence, there is one overidentifying restriction.

2.4 After July 1995 - LIP (Low Interest Rate Policy) Model

The following system of equations describes the Low Interest Rate Policy (LIP) model.

\[
\begin{align*}
u^{e} &= u^{e} + u^{mo} - u^{rd} - u^{cm} \\
u^{rd} &= u^{rd} \\
u^{cm} &= -\alpha u^{e} + v^{cm} \\
u^{re} &= -\beta u^{e} + v^{rd} \\
u^{m} &= v^{b} \\
u^{mo} &= \theta^{rd} v^{rd} + \theta^{cm} v^{cm} + \theta^{re} v^{re} + \theta^{b} v^{b} + v^{s}
\end{align*}
\]  

(12)

The structure of the LIP model differs from that of the CR model in equation (12). The equation indicates that the BOJ passively accommodates the demand shock for discount-window borrowing by private banks, \( v^{b} \). Equation (13) represents the open-market operations behavior of the BOJ. The LIP model assumes that the BOJ can use only open-market operations proactively to supply high-powered money. Therefore, the high-powered money supply shock, \( v^{s} \), is defined as the monetary policy shock of the BOJ in this model. Consequently, the LIP model may be written in the form of equation (3) as follows:

\[
\begin{align*}
u^{e} &= \begin{bmatrix} 1 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix} \psi^{ec} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} \psi^{cm} + \begin{bmatrix} 0 \\ 0 \\ 0 \\ 1 \end{bmatrix} \psi^{rd} \\
u^{re} &= \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix} \psi^{e} + \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} \psi^{cm} + \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix} \psi^{rd} \\
u^{mo} &= \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix} \psi^{e} + \begin{bmatrix} 1 \\ 1 \\ -1 \\ -1 \end{bmatrix} \psi^{cm} + \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix} \psi^{rd} \\
u^{b} &= \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix} \psi^{e} + \begin{bmatrix} 1 \\ 1 \\ -1 \end{bmatrix} \psi^{cm} + \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix} \psi^{rd} \\
u^{s} &= \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} + \begin{bmatrix} 1 \\ 0 \end{bmatrix} \psi^{e} + \begin{bmatrix} 1 \\ 1 \\ -1 \\ -1 \end{bmatrix} \psi^{cm} + \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix} \psi^{rd}
\end{align*}
\]  

One may also invert the above relationship to determine how the monetary policy shock, \( v^{s} \), depends on the VAR innovations:

\[
\begin{align*}
v^{s} &= -(\alpha \psi^{cm} + \beta \psi^{e}) u^{e} + (\theta^{b} + \theta^{s}) u^{mo} \\
&
- (\theta^{rd} + \theta^{re}) u^{re} - (\theta^{cm} + \theta^{re}) u^{cm} - (\theta^{rd} + \theta^{b}) u^{b}
\end{align*}
\]  

(14)

The LIP model described by the above structural VAR system has 11 unknown parameters (including the variances of five structural shocks) to be estimated from 15 covariances. Hence, there are four overidentifying restrictions.

2.5 Theoretical Models for Alternative Operating Procedures

Parameters in the BOJ behavior functions, given by equation (10) in the CR model and by equation (13) in the LIP model, define how the BOJ controls the market for bank reserves in each model. For example, the proposition that the BOJ targets only the call rate can be expressed in terms of three additional restrictions in the CR model, \( \psi^{rd} = 1 \), \( \psi^{cm} = 1 \) and \( \psi^{e} = 1 \), and four additional restrictions in the LIP model, \( \theta^{rd} = 1 \), \( \theta^{cm} = 1 \), \( \theta^{re} = 1 \) and \( \theta^{b} = -1 \). In this case, the monetary policy shocks can be recovered by the VAR innovations to the call rate. According to this proposition, the call rate provides the best policy indicator of the BOJ.

Alternative propositions that define the BOJ’s policy in terms of both the call rate and quantity indicators, such as currency and reser-
ves, can also be represented by parametric restrictions in the BOJ behavior functions. For example, the proposition that the BOJ targets both the call rate and reserves may be written in terms of two additional restrictions in the CR model, \( \psi^{a,b} = 1 \) and \( \psi^{a,c} = 1 \), and three additional restrictions in the LIP model, \( \theta^{a,b} = 1 \), \( \theta^{a,c} = 1 \), and \( \theta^{b} = -1 \). In this case, the policy shocks are recovered by linear combinations of the VAR innovations to the call rate and reserves. According to this proposition, a hybrid variable comprising the call rate and reserves provides a good policy indicator of the BOJ. Hence, imposing various parametric restrictions on equations (10) and (13), respectively, yields six alternative models that are nested within the CR and LIP models. In particular, we describe two of the six models as single-targeting models, which assume that the BOJ targets a single monetary variable, while four are described as mixed-targeting models, which assume that the BOJ targets a combination of the following policy-sector variables: the call rate, currency, reserves, and high-powered money (currency + reserves). Table 2 presents the models, which imply different forms of BOJ operating procedures. In what follows, we examine the BOJ’s policy indicator by estimating the six alternative models and the CR and LIP models.

### 2.6 Date, Estimation, and Results

As we explained in subsection 2.1, the Bernanke-Mihov methodology accommodates the inclusion of both policy variables and non-policy variables in the VAR system. In both the CR and the LIP models, the non-policy variables are the output gap \( y \) for the industrial production index (1995 = 100, seasonally adjusted) and the rate of inflation \( \pi \) in the consumer price index (1995 = 100, excluding food products). The X11 method was used to seasonally adjust the consumer price index. The output gap was measured by using percentage deviations from the trend, which was constructed using the Hodrick-Prescott filter. The inflation rate is annual.

### Table 2: Alternative Models for the BOJ’s Operating Procedures

<table>
<thead>
<tr>
<th>CR Model (Before June 1995)</th>
<th>BOJ Equations</th>
<th>Monetary Policy Shocks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Models</td>
<td>( \psi^{a,b} )</td>
<td>( \psi^{a,c} )</td>
</tr>
<tr>
<td>CL (Call Rate)</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>HP (High-powered Money)</td>
<td>1.00</td>
<td>0.00</td>
</tr>
<tr>
<td>CL-CU-RE</td>
<td>1.00</td>
<td>–</td>
</tr>
<tr>
<td>CL-CU</td>
<td>1.00</td>
<td>–</td>
</tr>
<tr>
<td>CL-RE</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>CL-HP</td>
<td>1.00</td>
<td>( \psi^{a} ) = ( \psi^{a} )</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LIP Model (After July 1995)</th>
<th>BOJ Equations</th>
<th>Monetary Policy Shocks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Models</td>
<td>( \psi^{a,b} )</td>
<td>( \psi^{a,c} )</td>
</tr>
<tr>
<td>CL (Call Rate)</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>HP (High-powered Money)</td>
<td>1.00</td>
<td>0.00</td>
</tr>
<tr>
<td>CL-CU-RE</td>
<td>1.00</td>
<td>–</td>
</tr>
<tr>
<td>CL-CU</td>
<td>1.00</td>
<td>–</td>
</tr>
<tr>
<td>CL-RE</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>CL-HP</td>
<td>1.00</td>
<td>( \psi^{a} ) = ( \psi^{a} )</td>
</tr>
</tbody>
</table>

1. CL, HP, CU, and RE imply the call rate, high-powered money, currency, and reserves, respectively.
2. We describe the CL and HP models as single-targeting models, which assume that the BOJ targets a single-monetary variable.
3. We describe the CL-CU-RE, CL-CU, CL-RE, and CL-HP models as mixed-targeting models, which assume that the BOJ targets a combination of the following policy-sector variables: CL, HP, CU, and RE.
Consider the policy variables in the VAR system. As we explained in subsections 2.3 and 2.4, the development of equilibrium models of the market for bank reserves involves the use of identities between assets and liabilities in the BOJ’s balance sheet (Table 1). In the LIP model, government deposits (GD), currency (CU), and reserves (RE) are used for liabilities. Furthermore, the assets held via open-market operations (MO), which comprise bills, bonds, and overseas assets acquired by the BOJ through these operations, are used for assets. In addition to these four variables, the call rate (R) is included in the policy sector. In the CR model, GD and CU are used for liabilities. In addition, the assets held via open-market operations and discount-window lending (MD), which are obtained by adding BOJ loans to MO, are used for assets. In addition to these three variables, R is included in the policy sector.

The reduced-form VAR system to be estimated for the CR model is the six-variable VAR system in \((y, \pi, GD, CU, R, MD)\). For the LIP model, we estimate the seven-variable VAR system \((y, \pi, GD, CU, RE, R, MD)\). To determine the number of lags in the VAR systems, we apply the Akaike Information Criterion (AIC). This criterion suggests 11 lags in the CR model and five lags in the LIP model. All data were obtained from the Nikkei NEEDS, and the sample period is from January 1976 to May 2003.

To estimate the models, we use a two-step procedure. The first step involves equation-by-equation OLS estimation. In the second step, full-information maximum likelihood estimation is applied. The log likelihood function to be maximized is as follows:

\[
L(I-G, A, \Sigma) = -(T/2) \log |I-G| - \log |A| - \log |\Sigma| - \frac{1}{2} \text{trace}((I-G)(A^{-1})\Sigma^{-1}A^{-1}(I-G)\Sigma)
\]

where \(\Sigma_n\) is the estimate of the covariance matrix of the policy-sector VAR innovations and \(\Sigma_p\) is the diagonal matrix that diagonally locates the variances of the structural shocks. We performed two types of test on the models: (1) tests of overidentifying restrictions on the validity of the full set of identifying restrictions; and (2) tests of joint hypotheses on the structural parameters, conditional on the validity of the CR and LIP models.

For ease of interpretation, we define ‘weighting parameters’, \(\omega\), in the CR, LIP, and mixed-targeting models. The weighting parameters are the absolute values of the parameters corresponding to the VAR innovations in the BOJ behavior functions, (10) and (13). Each of the absolute values in the behavior functions is normalized so that their sum is unity. For example, the weighting parameters in the CR model are given by

\[
\nu_m^{\omega} = -\omega_{f}u^{f} + \omega_{e}u^{e} + \omega_{m}u^{m} + \omega_{d}u^{d},
\]

where \(\omega_{f} + \omega_{e} + \omega_{m} + \omega_{d} = 1\).

In the estimation reported in Tables 3 and 4, we take into account the following points.

\[\text{Similarly, the weighting parameters in the LIP model are defined as:}\]

\[
\nu_{l}^{\omega} = -\omega_{f}u^{f} + \omega_{e}u^{e} - \omega_{m}u^{m} - \omega_{d}u^{d},
\]

where \(\omega_{f} + \omega_{e} + \omega_{m} + \omega_{d} = 1\).
Table 3: Estimation Results from the Credit Rationing (CR) Model  

<table>
<thead>
<tr>
<th>Models</th>
<th>Demand Equations</th>
<th>BOJ Equations</th>
<th>OIR</th>
<th>Joint</th>
<th>Weights</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\alpha$</td>
<td>$\beta$</td>
<td>$\phi^{d}$</td>
<td>$\phi^{u}$</td>
<td>$\phi^{h}$</td>
</tr>
<tr>
<td>CR</td>
<td>0.05 (0.05)</td>
<td>0.05 (0.02)</td>
<td>0.99 (0.01)</td>
<td>0.99 (0.12)</td>
<td>0.96 (0.01)</td>
</tr>
<tr>
<td>CL</td>
<td>0.03 (0.02)</td>
<td>0.01 (0.01)</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>HP</td>
<td>0.03 (0.01)</td>
<td>0.03 (0.00)</td>
<td>1.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>CL-CU-RE</td>
<td>0.11 (0.05)</td>
<td>0.08 (0.04)</td>
<td>1.00</td>
<td>0.92 (0.15)</td>
<td>0.95 (0.13)</td>
</tr>
<tr>
<td>CL-CU</td>
<td>0.03 (0.01)</td>
<td>0.01 (0.02)</td>
<td>1.00</td>
<td>0.99 (0.01)</td>
<td>0.99 (0.01)</td>
</tr>
<tr>
<td>CL-RE</td>
<td>0.03 (0.02)</td>
<td>0.02 (0.02)</td>
<td>1.00</td>
<td>1.00</td>
<td>0.99 (0.03)</td>
</tr>
<tr>
<td>CL-HP</td>
<td>0.04 (0.02)</td>
<td>0.02 (0.03)</td>
<td>1.00</td>
<td>0.99 (0.03)</td>
<td>0.99 (0.03)</td>
</tr>
</tbody>
</table>

1. For the Demand Equations and BOJ Equations, standard errors are in parentheses.
2. OIR and Joint indicate overidentifying restrictions test statistics and joint test statistics, respectively. P-values are in parentheses.
3. A likelihood ratio test was used to test the overidentifying restrictions. The degrees of freedom are one for the CR model, four for the CL and HP models, two for the CL-CU-RE model, and three for the CL-CU, CL-RE, and CL-HP models.
4. A likelihood ratio test was used to test the joint hypotheses. The degrees of freedom are three for the CL and HP models, one for the CL-CU-RE model, and two for the CL-CU, CL-RE, and CL-HP models.

Table 4: Estimation Results from the Low Interest Rates (LIP) Model  

<table>
<thead>
<tr>
<th>Models</th>
<th>Demand Equations</th>
<th>BOJ Equations</th>
<th>OIR</th>
<th>Joint</th>
<th>Weights</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\alpha$</td>
<td>$\beta$</td>
<td>$\phi^{d}$</td>
<td>$\phi^{u}$</td>
<td>$\phi^{h}$</td>
</tr>
<tr>
<td>LIP</td>
<td>0.06 (0.03)</td>
<td>0.43 (0.02)</td>
<td>0.99 (0.03)</td>
<td>0.92 (0.11)</td>
<td>0.61 (0.03)</td>
</tr>
<tr>
<td>CL</td>
<td>0.04 (0.03)</td>
<td>0.25 (0.05)</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>HP</td>
<td>0.05 (0.01)</td>
<td>0.31 (0.02)</td>
<td>1.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>CL-CU-RE</td>
<td>0.07 (0.03)</td>
<td>0.43 (0.03)</td>
<td>1.00</td>
<td>0.88 (0.03)</td>
<td>0.61 (0.03)</td>
</tr>
<tr>
<td>CL-CU</td>
<td>0.15 (0.05)</td>
<td>0.14 (0.05)</td>
<td>1.00</td>
<td>0.99 (0.01)</td>
<td>1.00</td>
</tr>
<tr>
<td>CL-RE</td>
<td>0.05 (0.02)</td>
<td>0.41 (0.02)</td>
<td>1.00</td>
<td>1.00</td>
<td>0.58 (0.04)</td>
</tr>
<tr>
<td>CL-HP</td>
<td>0.04 (0.02)</td>
<td>0.15 (0.01)</td>
<td>1.00</td>
<td>0.99 (0.06)</td>
<td>0.99 (0.06)</td>
</tr>
</tbody>
</table>

1. For the Demand Equations and BOJ Equations, standard errors are in parentheses.
2. OIR and Joint indicate overidentifying restrictions test statistics and joint test statistics, respectively. P-values are in parentheses.
3. A likelihood ratio test was used to test the overidentifying restrictions. The degrees of freedom are four for the LIP model, eight for the CL and HP models, six for the CL-CU-RE model, and seven for the CL-CU, CL-RE, and CL-HP models.
4. A likelihood ratio test was used to test the joint hypotheses. The degrees of freedom are four for the CL and HP models, two for the CL-CU-RE model, and three for the CL-CU, CL-RE, and CL-HP models.
1. For the pre-June 1995 period, the parameter estimates of the BOJ behavior function in the CR and mixed-targeting models are close to unity. This is consistent with the CL model being the most easily accepted, and with the estimates of \( \omega' \) being relatively high. Furthermore, all other models except the HP model are easily accepted. These results indicate that the call rate is the best policy indicator of the BOJ for the period before June 1995.

2. For the post-July 1995 period, the single-targeting models, the CL and HP models, are rejected at the five-percent level of significance. On the other hand, the LIP model and two mixed-targeting models, the CL-CU-RE and CL-RE models, are easily accepted. In particular, the estimates of \( \alpha \) in the three models indicate that the BOJ has been equally concerned about the call rate and reserves. These results suggest that an equally weighted average of the call rate and reserves can be used as the policy indicator of the BOJ in this period.

2.7 The Actual Policy Measure of the BOJ

The estimation results suggest that the composition of the BOJ’s policy measure might differ between periods. Hence, to calculate a useful policy measure over time, we applied the method proposed by Bernanke and Mihov. First, we calculated the sum of the policy shock and the corresponding element of \( A^{-1} (I - G) P_t \). Specifically, in terms of equation (3), this is the fourth element in the case of the CR model and its six alternative models, and is the fifth element in the case of the LIP model and its six alternative models. This procedure generated seven series in each period, pre-June 1995 and post-July 1995. Next, we normalized the P-values of the tests of the overidentifying restrictions performed in each subperiod so that the sum of their values is unity. Using the normalized P-values, we derived a weighted average policy measure in each period. Then, we normalized the calculated policy measure at each date by subtracting it from a 36-month moving average of its own past values over the entire period. This implies that zero is the benchmark for ‘normal’ monetary policy (normal at least in terms of recent experience). The historical values are referred to as the ‘actual policy measure’ of the BOJ. Figure 2 shows the obtained policy measure from January 1980 to May 2003. Several features are noteworthy.

\[ \text{Figure 2: The Bank of Japan’s Policy Measure} \]

11) In all 14 models, the parameter estimates of the demand functions are of the expected sign, although some estimates are not statistically significant.

12) In March 2001, the BOJ officially adopted a new operating procedure, by targeting the level of reserves as much as continuing the so-called zero interest rate policy. Indeed, estimates for the period before February 2001 confirmed that the BOJ targeted only the call rate. This result does not necessarily contradict the above observation, which was obtained by also using the sample period from March 2001. This is because the observations to May 2003 quantitatively reflect the BOJ’s operating procedures since March 2001 as well as those to February 2001. Furthermore, splitting the sample at March 2001 considerably limits the sample for estimation of the LIP model. Therefore, for the second period, we conduct our analysis without splitting the sample.

13) Positive values indicate an easing of monetary policy, while negative values indicate tightening. The actual policy measure is scaled so that it has the same variance as the call rate.
1. After a temporary tightening immediately following the Plaza Agreement of September 1985, the policy stance in the late 1980s was expansionary.
2. In the early 1990s, the policy stance was contractionary, and this burst the bubble economy in the late 1980s.
3. In the mid 1990s, the policy stance was extremely expansionary at the beginning of the period of the low interest rate policy in June 1995.
4. After a temporary tightening involving raising the call rate in August 2000, the policy stance has since been neutral.

3 Discussion

The previous section has presented a policy measure of the BOJ that represents its past policy decisions over time. This section discusses the plausibility of the obtained policy measure by using impulse response functions.

Analogously to Bernanke and Mihov’s VAR system, given by equations (1) and (2), we assume that the economy is described by the following linear structural model:

\[ Y_t = \sum_{i=0}^k B_i Y_{t-i} + \sum_{i=1}^k C_i \pi_{t-i} + A \eta_t \]

\[ P_t = \sum_{i=0}^k D_i Y_{t-i} + \sum_{i=1}^k G_i \pi_{t-i} + \phi_t, \]

where \( P_t \) is the actual policy measure. The vector of non-policy variables in the VAR is given by \( Y_t = (y_t, \pi_t) \), which includes the output gap for industrial production (\( y_t \)) and the rate of inflation (\( \pi_t \)). The \( \eta_t \) and \( \phi_t \) terms indicate the uncorrelated structural disturbances, an output shock, an inflation shock, and a policy shock to the system. The AIC suggests the use of 13 lags in the VAR system. The identification of the structural shocks is achieved through a Choleski decomposition, with the ordering of the variables as \( y_t, \pi_t, \phi_t \).

Table 5: Structural Change Tests of VAR System

<table>
<thead>
<tr>
<th></th>
<th>Output Gap</th>
<th>Inflation</th>
<th>Policy Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Test</td>
<td>Asymptotic</td>
<td>Test</td>
</tr>
<tr>
<td></td>
<td>statistics</td>
<td>p-values</td>
<td>statistics</td>
</tr>
<tr>
<td>Sup LM</td>
<td>67.6</td>
<td>0.08</td>
<td>61.8</td>
</tr>
<tr>
<td>Exp LM</td>
<td>29.4</td>
<td>0.09</td>
<td>25.9</td>
</tr>
<tr>
<td>Ave LM</td>
<td>43.7</td>
<td>0.25</td>
<td>40.7</td>
</tr>
</tbody>
</table>

1. The output-gap equation, the inflation equation, and the policy measure equation are estimated with 13 lags, respectively.
2. LM denotes the Lagrange multiplier statistic of the null hypothesis of no structural change.
4. Asymptotic p-values for the structural change tests are computed using the methodology proposed by Hansen (1997).

First, we examine the stability of the reduced-form VAR by employing the three types of Lagrange multiplier (LM) test, the Sup LM, the Exp LM, and the Ave LM test, proposed by Andrews (1993) and Andrews and Ploberger (1994). In the tests of structural change, the null hypothesis of parameter stability of the output gap, the inflation equation, and the policy equation is each tested against the alternative hypothesis of parameter instability. Further, we use the methodology presented by Hansen (1997) to calculate asymptotic p-values for the structural change tests. 14

Table 5 reports the test results of parameter stability for the output gap, the inflation equation, and the policy equation. For our estimated output-gap equation, the p-values of the Sup LM, the Exp LM, and the Ave LM test statistics are 0.08, 0.09, and 0.25, respectively. For the inflation equation, the corresponding p -values are 0.21, 0.29, and 0.42. Further, for the policy equation, the p-values are 0.42, 0.44, and 0.59. Overall, our estimated VAR system

14 We compute the LM test statistics and the corresponding p-values using the GAUSS code programmed by Professor Bruce Hansen. The LM statistics are computed using the middle 70 percent of the sample.
Figure 3: Impulse Response to Policy Shock
1. The figure shows the estimated impulse response to a one standard deviation policy shock.
2. The solid line and the dashed line represent point estimates and their 95 percent confidence intervals, computed by using a Monte Carlo integration with 1000 replications, respectively.

Figure 4: Impulse Response to Output Shock and to Inflation Shock
1. The left column shows the estimated responses to a positive output shock, while the right column shows the estimated responses to an inflation shock.
2. The solid line and the dashed line represent point estimates and their 95 percent confidence intervals, computed by using a Monte Carlo integration with 1000 replications, respectively.

Dashed lines represent their 95 percent confidence intervals, computed by using a Monte Carlo integration with 1000 replications. The effect of the expansionary policy shock on output builds gradually and reaches its peak after about one year, before declining back to zero. The timing of the estimated peak and decline of output corresponds to the estimated timing of the 'policy tightening', which indicates that the policy measure becomes negative about one year after...
the expansionary shock. The effect on the inflation rate exhibits a modest ‘price puzzle’ and reaches its peak in about two years. The left column of Figure 4 shows the estimated responses to a positive output shock, while the right column shows the estimated responses to an inflation shock. The impulse response conveys a plausible story: positive innovations to the output and the inflation lead to policy tightenings, as captured by falls in the policy measure. The pattern seems to confirm the “leaning against the wind” story. These impulse response results suggest that the obtained policy measure is plausible.

4 Conclusion

The main conclusion of this paper is that no simple monetary measure represents the BOJ’s past policy decisions over time. In particular, we suggest that the call rate should be used as the policy indicator of the BOJ to June 1995, and that an equally weighted average of the call rate and reserves should be used as the BOJ’s policy indicator from July 1995.

This paper, by applying Bernanke and Mihov’s methodology, has presented a useful measure of BOJ policy that identifies its past policy decisions over time. One could use this indicator to conduct various exercises, including comparative analyses of the BOJ’s actual and optimal decisions. An attempt along these lines can be found in my related work (Nakashima 2004).15

Appendix A: Constructing MO and MD

• Construction of MO:
First, we apply X11 to foreign assets (net), claims on government, claims on deposit-money banks, lending to deposit-money banks, and unclassified assets (net). Second, we subtract lending to deposits money banks (SA) from the claims on deposit-money banks (SA). The transformed data measure claims that the BOJ acquires via openmarket operations on deposit-money banks. Then, we define the sum of the transformed data, foreign assets (SA), claims on government (SA), and the unclassified assets (SA) as MO: the BOJ’s assets held via open-market operations. All the data are obtained from Nikkei NEEDS (Monetary Survey, Accounts of Monetary Authority).

• Construction of MD:
After applying X11 to lending to deposit-money banks, we define the sum of lending (SA) and MO as MD: the BOJ’s assets held via openmarket operations and discount-window lending.

References

15) The resulting policy measure is obtainable from the author.

16) SA denotes seasonally adjusted data.
Quarterly, 35–2, 159–180.