

(201)
212.037
1/653

Economics Working Paper 216*

Identifying Monetary Policy Shocks in Japan[†]

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April 1997



Keywords: Monetary policy, structural VAR, identification.

Journal of Economic Literature classification: E52, E58, C32.

* This paper is also number 28 Finance and Banking Discussion Papers Series, UPF.

[†] This is a revised version of the paper previously titled "Identifying Monetary Policy in Japan". I am grateful to Christopher A. Sims for his discussion. I would also like to thank Fabio Canova, Hiroshi Fujiki, Akiyoshi Horiuchi, Jane Marrinan, David Prentice, Xavier Sala-i-Martin, Towa Tachibana, Yosuke Takeda, and Geoffrey E. Wood and other participants of the CEPR meeting of the Network on the Japanese Economy (December 1996) for their comments. Research for this paper was partly financed by the DGICYT grant PB94-1095.

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Abstract

It is sometimes argued that the central banks influence the private economy in the short run through controlling a specific component of high powered money, not its total amount. Using a structural VAR approach, this paper evaluates this claim empirically, in the context of the Japanese economy. I estimate a model based on the standard view that the central bank controls the total amount of high powered money, and another model based on the alternative view that it controls only a specific component. It is shown that the former yields much more sensible estimates than the latter.

1 Introduction

There have been debates in many countries over how the central banks intervene in the private economy. The main purpose of this paper is to give an empirical evaluation to this debate in the context of Japanese monetary policy.

The debate concerns how the central bank tries to send initial impact of its policy changes to the private sector. Standard macroeconomic theories assume that the central bank influences the private economy through changing the total amount of high powered money. But whether this assumption holds true in practice has been questioned by some monetary economists. They argue that the central bank cannot, or chooses not to, control the total amount of high powered money. Despite this inability (or inaction), it does control some specific component of high powered money and through this influences the private economy. For example, in the US, Goodfriend (1983) and Strongin (1995), among others, have argued that the Fed targets the amount of nonborrowed reserves in order to affect the short term interest rate, taking as given the total amount of high powered money or reserves. Some German economists argue that, until recently, the Bundesbank used discount-window borrowing quotas as an important policy tool (see Bernanke and Mihov (1996)).

Japan also has its share of monetary economists who believe in a similar argument. According to them, the Bank of Japan cannot control the total amount of high powered money in the short run, but nevertheless affects the interest rate by changing the amount of Bank of Japan Loans, which is a component of high powered money. To the best of my knowledge, this has never been evaluated empirically using sophisticated econometric methods. This paper takes advantage of recent methodological innovations in studies of monetary policy to do just that. I estimate two time series models, one that represents the standard view that the Bank of Japan controls the total amount of high powered money, and the another that represents the alternative view mentioned above. I study which model yields estimates that are closer to predictions of theory and then study quantitative implications from that model found to be more appropriate.

More specifically, this paper confronts three main issues:

- (1) Does the Bank of Japan intervene primarily in the market for **total** high powered money, or does a **specific component** of high powered money comprised of central bank loans play a special role in its monetary policy?
- (2) Is the policy rule of the Bank of Japan best characterized as an interest rate targeting or a monetary aggregate targeting rule,

or should it be considered as a partial accommodation rule (mixed targeting)?

(3) Does monetary policy in Japan play an important role in determining output, consumption, investment and the price level in Japan?

I try to answer those questions by using the structural VAR approach, which allows me to explicitly model the short run interaction between the central bank and private sector.

On the technical side, I incorporate the newly developed method of Sims and Zha (1995) for calculating error bands around estimated impulse response functions. Until recently, the correct method for such computation for overidentified structural VAR models was not known.

The results are as follows. First, the evidence is decisively in favor of the standard view that the central bank intervenes in the market for total high powered money. Its specific component does not play any special role. Second, I also find that the short run policy rule of the central bank is neither pure interest targeting nor pure monetary aggregate targeting but is partial accommodation. Third, identified policy shocks have important effects on quantity variables such as output, but less important effects on the price level, especially in the short run. Finally, my estimates are shown to be free from some problems that are common to many existing studies, such as the "liquidity puzzle" or the "price puzzle".

The rest of the paper is organized as follows. Section 2 offers an overview of related literature. Section 3 discusses the empirical methodology. Section 4 explains data used in the analysis. In section 5, I describe the two alternative models for the Japanese monetary policy. Section 6 discusses estimation results. Section 7 concludes.

2 Overview

2.1 Problems with the traditional approach

In this and the next subsections I briefly review the literature on identification of monetary policy shocks. A more exhaustive review can be found in Leeper, Sims and Zha (1996).

Recent efforts to identify monetary policy using time series data started with Sims (1972). After Sims (1980) it became common practice to use the VAR approach. At an early stage of this literature most studies identified innovations in the money stock as monetary policy shocks. However, this approach was

found to suffer from a problem now known as the “liquidity puzzle”: in the data measured innovations in money are often followed by a significant increase in the interest rate, while, theory predicts that a loosening of monetary policy should decrease the interest rate. It has been suggested that this is because a large fraction of measured innovations in the money stock actually reflects money demand shocks, rather than money supply shocks. This is true when the central bank tries to mitigate fluctuations of the interest rate in the face of fluctuating money demand by supplying money in an accommodating way. Because of this, some researchers propose using innovations in the short term interest rate as an alternative indicator of policy. However, this identification scheme has its own shortcoming: it was found that a positive innovation in the interest rate, which supposedly indicates a tightening of monetary policy, was actually followed by an increase in the price level, not a decrease. This is sometimes called the “price puzzle” (Strongin (1995)).

2.2 Recent development

In an effort to overcome those problems recent studies have made important progress in three directions.

First, some economists have noted that it is probably too extreme to assume that monetary policy shocks can be identified as innovations in any single variable. When the central bank follows a partially accommodating money supply rule, neither money stock nor the interest rate would be an appropriate index for monetary policy in itself. To give a simple illustration, suppose that the demand and supply behaviors in the money market in the short-run can be modeled in terms of two variables, M (money stock) and R (the interest rate). If the central bank follows the “money supply targeting rule” or the “fixed- M rule”, the money supply behavior is characterized by a vertical line in the (R, M) plane. In that case, a shock to monetary policy is identified as an innovation in M . On the other hand, if the monetary authority fixes the interest rate and fully accommodates the demand for money at that rate, the “money supply curve” becomes horizontal, and autonomous changes in policy are appropriately measured by innovations in the interest rate. If the central bank follows a partially accommodating rule, the reaction curve of the monetary authority becomes an upward sloping line in the (M, R) plane. In this case, any monetary policy shock, as well as demand shocks, will be split between innovations in R and M . This complicates the identification scheme. The reason is that now that M and R are simultaneously determined in this model, the standard VAR approach, which assumes a contemporaneous recursive structure, becomes unusable for policy analysis. For that reason, some papers employ the structural VAR approach, which does not necessarily assume the recursive structure. Refer to Sims (1986) and Gordon and Leeper (1994).

Second, a new line of research emerged aimed at solving the price puzzle. Sims

(1992) suggested that this puzzle is a symptom of an omitted variable problem. Suppose that there is a variable which affects the price level positively with some lag. Assume further that this variable is observable to the central bank but is omitted from a VAR model. A positive innovation in this variable is likely to be followed by a tightening of monetary policy. If the central bank does not fully offset the effect of this increase, to the eyes of econometricians it would look as if the tightening of monetary policy caused inflation. Following this intuition, there have been some studies experimenting on including various variables that could serve as an important leading indicator for future inflation. Sims (1992) includes the commodity price index and the exchange rate. Sims and Zha (1996) include the crude material price and the intermediate goods price indices. Gordon and Leeper (1994) include the long interest rate to capture changes in the expected inflation rate, which is expected to be reflected in changes in the term structure. Kim and Roubini (1996), who study monetary policy in G7 countries including Japan, include oil prices and the US federal funds rate for similar purposes.

Third, economists began to pay more attention to the variables that are under direct control of the central bank, rather than monetary aggregates such as M2 which might be more "contaminated" by shocks from the private sector. This shift has led to a debate on which variables the central bank controls actively in the short-run. In the US Sims (1992) and Bernanke and Blinder (1992) argue that the Federal Funds Rate is the best indicator of the Fed's monetary policy (although, as I have stated, this approach suffers from the price puzzle problem). Eichenbaum (1992) identifies innovations in nonborrowed reserves as monetary policy shocks, and shows that his identification scheme does not suffer from the liquidity puzzle nor the price puzzle. Strongin (1995) argues that changes in nonborrowed reserves that are orthogonal to changes in total reserves captured monetary policy better. Bernanke and Mihov (1995) compare performance of those models and conclude that, depending on the period, either the Federal Funds Rate or the Strongin measure is the most plausible indicator of monetary policy.

2.3 Debate over the conduct of the Bank of Japan

The primary objective of this paper is to take advantage of the recent developments in the literature to make an empirical evaluation of a long standing debate on the workings of Japanese monetary policy. The debate concerns how the Bank of Japan exerts its influence on the financial sector of the economy in the short run. A good survey can be found in Iwata (1993). Some argue that the Bank of Japan primarily intervenes in the market for **high powered money** (Iwata (1993)). Others argue that the central bank cannot influence the total amount of high powered money in the short run. They argue that, instead, the central bank intervenes in the market for the **Bank of Japan Loans**, which is one of

the components of high powered money, and through this influences the interest rate (Yokoyama (1977)).

The first of the two views stated above is the standard view that appears in any textbook of monetary economics and does not require any further comments. The latter view, on the other hand, requires some explanation. According to Iwata (1993), this theory consists of two main propositions. The first proposition is that the central bank "cannot" control the amount of high powered money or the money stock. This is because the amount of money stock is determined by the behavior of the private business sector which is beyond control of the central bank (note that, here, they are ignoring the role of the interest elasticity of money demand), and the amount of money stock determines the amount of high powered money through a stable money multiplier (excess reserve holdings by the private banks in Japan are practically zero, and therefore the multiplier is expected to be unaffected by the interest rate). The second proposition is that, despite the first proposition, the central bank can still influence the interest rate through changing the composition among various ways of supplying high powered money. In particular, they emphasize the role of the Bank of Japan Loans (hereafter BL). BL is a part of high powered money that is supplied in the form of lending from the central bank to large commercial banks through the discount window. The discount rate, the interest rate that is applied to this lending, is usually set lower than the interbank money market rate. For that reason, at first glance, it would look as if it were more advantageous for the commercial banks to borrow from the central bank. However, according to the proponents of this view, this is not so: borrowing from the central bank in fact accompanies a larger cost than borrowing from other commercial banks at the same interest rate. The reason is that borrowing more from the central bank means a closer surveillance by the central bank on daily activities of the borrowing bank. Also, borrowing large amounts from the central bank lowers the reputation of the private bank inside the financial sector. Note that this view is very similar to the argument put forth by Strongin (1995) for the US, which claims that an increase of borrowed reserves accompanies an implicit cost to a private bank. In addition, Okina (1991) argues that the central bank possesses various "arts" to increase the effective cost of borrowing from them. It is conceivable that it applies these arts more mercilessly when the amount of outstanding loans is high. For those reasons, an increase in BL induces the commercial banks to increase demand for borrowing from the fellow commercial banks, and therefore puts an upward pressure on the interbank money market rate. Hence, in the (R, BL) plane, the demand curve for BL would appear as an upward sloping line: as BL increases, the cost of borrowing from the central bank increases, and the commercial banks increase the demand for borrowing in the interbank money market, and thus the interest rate rises. This happens up to the point where R is equal to the cost of borrowing from the central bank. On the other hand, the behavior of the central bank is depicted

by a downward sloping supply curve. When the central bank decides to take a tighter policy stance, the supply curve shifts to the right and both R and BL increase.

On the other hand, proponents of the standard view argue that different ways of supplying high powered money have identical effects on the private economy. They question the validity of the claim that the cost of borrowing from the central bank is related to the amount of BL . The alleged costs are mostly subjective ones, and would not affect profit maximization conditions of commercial banks. Also, no empirical work has quantitatively demonstrated the existence of such costs. Hence, according to this view, BL is determined by some institutional factors that are irrelevant for the private economy.

Unfortunately, there have not been many empirical studies that have tried to evaluate the appropriateness of either of these views. In this paper I attempt to initiate a new debate based on empirical assessments of these two sharply differing views of monetary policy by estimating two versions of structural VAR models, each of which represents one of the two competing views. The two differ from each other only in their specification of the short run policy rule. I will compare their statistical performances as well as how much the estimates make sense in light of economic theory.

2.4 Complete vs. Partial vs. Zero Accommodation

Another closely related, but nevertheless separate, issue in this paper is whether the policy rule of the Bank of Japan can be characterized as complete accommodation (interest rate targeting), zero accommodation (targeting of monetary quantities), or whether it should be regarded as a partial accommodation rule¹. Note that any of the three rules can be consistent with either of the two models mentioned above. For example, we could have a central bank that intervenes in the market for high powered money and follows a partial accommodation rule there, or a central bank that intervenes in the market for the Bank of Japan Loans and follows a strict quantity targeting there. Therefore, this second issue should be considered as separate from the first.

In estimating the two models, I will allow for all three possibilities and empirically determine which is more likely to be the actual rule employed by the Bank of Japan. The structural VAR methodology offers an ideal tool for such analysis.

¹Ueda and Uekusa (1987) and Yoshikawa (1996) argue that the short run policy rule of the Bank of Japan is close to the interest rate targeting.

2.5 Time Series Analysis of Japanese Monetary Policy

Many studies (for example, Yoshikawa (1996)) have used the standard VAR approach to investigate the effects of monetary policy in Japan, but to my knowledge, none have confronted the issue of high powered money vs. BL. Of course, by using the standard VAR which assumes a short run recursive structure, these authors impose certain forms of the short run policy rule on their model, rather than estimating it.

More recent studies have used the structural VAR approach to study effects of monetary policy in Japan. Possibly the earliest of these is Iwabuchi (1990). He estimates a structural VAR model, where all six variables included are simultaneously determined. Although he explicitly formulates an equation that looks like an equation for the central bank behaviors, he does not take any specific view on which of the shocks generated by his model can be considered as a monetary policy shock, and studies responses to shocks to the interest rate, money supply, and commercial bank lending separately. Thus, this paper does not explicitly study the issue of complete vs. partial vs. zero accommodation. Nor does it take up the issue of high powered money vs. BL. A problem with this work is that the error bands for the impulse response functions are not computed, and so it is difficult to judge how important the results drawn from the analysis are.

West (1993) also uses the structural VAR approach to study contributions of various shocks to Japanese business cycles, with a particular focus on effects of monetary policy. He uses money supply as the only policy tool and never explicitly introduces the interest rate in his analysis. Thus the analysis never confronts the issue of complete vs. partial vs. zero accommodation directly. It is also impossible to know if the identified policy shocks suffer from the problem of the liquidity puzzle, since the response of the interest rate to the shock is not studied. Therefore, the analysis fails to provide an important criterion with which we could judge if the identified policy shocks can be reasonably considered as a pure representative of autonomous changes in policy or if they are contaminated by shocks to the money demand side. Moreover, this paper, like the Iwabuchi paper, does not present error bands around impulse response functions, and thus it is difficult to judge how important the results drawn from the analysis are.

Kasa and Popper (1995) is closely related to this paper. They use a structural VAR model similar to the one developed by Bernanke and Mihov (1995) for the US to study the short run characteristics of the Japanese monetary policy rule. Their study is unique in their use of "nonborrowed reserves" variable for Japan. According to their results, the policy rule is characterized by a mixed targeting of both nonborrowed reserves and the call rate. There are three problems concerning the use of this nonborrowed reserves variable. First, the Bank of Japan itself has never indicated that it considers nonborrowed reserves as a target (Ueda

(1991)). Second, these authors compute nonborrowed reserves as Reserves, which is Line 20 for Japan in the International Financial Statistics (IMF) minus Credit from the Central Bank, which is Line 26G of the same source. But those series do not correspond to the notions of Bank Reserves and Borrowing from the Central Bank normally used in the literature on Japanese monetary policy. Third, non-borrowed reserves thus computed consistently take negative values, especially for recent periods. As theoretical implications of changes in "negative nonborrowed reserves" are not clear, interpretation of policy shocks thus identified has to be questioned². Another problem with their analysis is that impulse responses to the identified policy shocks are not presented, and therefore readers are deprived of important measures to judge how reasonable their identification scheme is.

Kim (1996) and Kim and Roubini (1996) estimate VAR models for major industrialized countries, including Japan, to study effects of monetary policy. They try to identify monetary policy shocks by assuming that the central bank responds immediately to external shocks such as innovations in oil prices, while those shocks do not affect money demand directly. Both papers allow for simultaneous determination of the interest rate and money stock and obtain reasonable estimates. They do not take up the issue of high powered money vs. BL.

3 Statistical methodology

This paper employs the structural VAR developed by Sims (1986), Bernanke (1986) and Blanchard and Watson (1986)³. This method imposes identification restrictions on short-run relationships, without making strong assumptions on medium to long-run relationships. A reason for choosing this methodology is that the identification scheme in this paper relies heavily on assumptions of institutional rigidities and information lags, which are likely to be valid in the short-run only. In this sub-section, I will briefly discuss the methodology. Define a VAR model in a vector of variables $y(t)$ ($N \times 1$) as

$$y(t) = B(L) \cdot y(t) + u(t), \quad (1)$$

where $B(L)$ is a polynomial in the lag operator L , and $u(t)$ is the residual vector. The components of $u(t)$ ($N \times 1$) are not generally orthogonal to each other,

²The definition of "Bank Reserves" that is more often used in the literature is "Deposits from Deposit Money Banks" in "Monetary Survey" of the *Economic Statistics Monthly*, Bank of Japan. The "Borrowing from the Central Bank" often used in the literature is "Loans and Discounts" on the asset side of the Bank of Japan Accounts, from the same source ("BL" in this paper). If we define "nonborrowed reserves" as the difference between the two, we still find that, for recent periods, it almost always takes negative values.

³A related approach is the VAR with restrictions on long-run relationships. Refer to, for example, Blanchard and Quah (1989) and Shapiro and Watson (1988). Gali (1992) combined both short run and long run restrictions.

and it is usually hard to interpret those residuals in economic terms. Hence the usual practice is to decompose those residuals into mutually orthogonal shocks with economic interpretations, such as “monetary policy shocks”. Let $\epsilon(t)$ be a $(N \times 1)$ vector of such structural shocks, and assume that

$$\Gamma_0 \cdot u(t) = \epsilon(t). \quad (2)$$

or,

$$u(t) = (I - \Gamma_0) \cdot u(t) + \epsilon(t) \quad (3)$$

From 2,

$$\Sigma = \Gamma_0^{-1} \cdot \Sigma_\epsilon \cdot \Gamma_0^{-1'}, \quad (4)$$

where Σ is the variance-covariance matrix for the vector $u(t)$. In the standard (unrestricted) VAR model, the $(N \times N)$ matrix Γ_0 and the variance-covariance matrix of $\epsilon(t)$ (denoted Σ_ϵ) are identified by assuming that Γ_0 is a triangular matrix (which amounts to assuming a contemporaneous recursive relationship) with its diagonal terms normalized to one, and that Σ_ϵ is a diagonal matrix. Under those assumptions, equation 4 can be solved for Γ_0 and Σ_ϵ by applying the Cholesky decomposition. This approach is unusable here because I wish to estimate models in which the interest rate and monetary aggregates are simultaneously determined.

The structural VAR allows more general forms of restrictions to be imposed on the matrices Γ_0 and Σ_ϵ . Identification is accomplished through maximizing a log likelihood function of the form

$$F = \frac{T}{2} \cdot \ln(\det(\Gamma_0^{-1} \cdot \Sigma_\epsilon \cdot \Gamma_0^{-1'})) - \frac{T}{2} \cdot \text{trace}(\Gamma_0' \cdot \Sigma_\epsilon^{-1} \cdot \Gamma_0 \cdot \Sigma), \quad (5)$$

with respect to the free parameters in Γ_0 and Σ_ϵ (T is the number of observations). Thus, this method requires identification restrictions only on short-run relationships, leaving the reduced form VAR in equation 1, and thus medium to long-run relationships between the variables, unrestricted.

The correct way to compute error bands for an overidentified VAR model is given in Sims and Zha (1995). Define a matrix A_0 as

$$A_0 \equiv \Sigma_\epsilon^{-1/2} \cdot \Gamma_0 \quad (6)$$

Hence, from equation 5, the log likelihood function is rewritten as

$$F = T \cdot \ln(\det(A_0)) - \frac{T}{2} \cdot \text{trace}(A_0 \cdot \Sigma \cdot A_0'). \quad (7)$$

Take a second-order Taylor expansion around the peak of the above log likelihood function with respect to the free elements of A_0 , and the normal distribution from which Monte Carlo samples are generated is obtained. The draws are weighted by the ratio between the F in equation 7, the true distribution, and the approximated distribution from which the draws are made.

4 Choice of Variables

Throughout the paper, monthly data is used because the identification restrictions in this analysis are most valid in the very short-run. Detailed descriptions of the data series are given in the Appendix. Variables used in the estimation are:

OP: Oil Price Index,

P: Consumer Price Index,

SPEND: Living Expenditure of All Households,

ORDER: New Orders for Machinery (SA),

Y: Industrial Production (SA),

R: Short-term Interest Rate (the Call Market Rate),

M: Money Stock (M2+CD, SA),

H: High Powered Money (adjusted for reserve requirement ratio changes, SA)

BL: Bank of Japan Loans Outstanding.

In the above, "SA" means seasonally adjusted. Except for R, all the series are expressed in natural logarithms. I divide the logs of OP, ORDER and BL by 10 because I find that this tends to make convergence of the iterative estimation procedure faster. This does not affect the qualitative results in any way, other than the matter of scaling. R, which was originally in percentage form, is divided by 100. The sample period is February, 1977 to May, 1995. The choice of the starting period is dictated by data availability: the data on H was available only from January 1976. As the maximum lag used in the analysis is 13, the sample starts from thirteen months later. There are other reasons for focusing on the post oil crisis period. First, Takeuchi (1991) shows that there were major structural breaks in most of the important macroeconomic time series data in Japan between 1970 and 1973. Second, it is widely believed that there was a major structural change in the Bank of Japan's policy stance around early 1975. In July 1975, the Bank declared that it had abandoned the old multi-target policy and adopted M2+CD as its most important intermediate target (Ito (1989), the Bank of Japan (1986)).

Some of the variables I choose to include are conventional ones: P, Y, R and M show up in almost all the empirical studies in the literature. Motivation behind the inclusion of H and BL is obvious, as the objective of this study is to investigate their roles in monetary policy in Japan. The inclusion of OP, SPEND, and ORDER requires some more explanation.

OP is the average of oil prices across different spot markets, measured in US dollars. This variable is included because it is an important leading indicator for inflation in Japan. To demonstrate this point, I computed cross correlation between the lagged and lead OP (log differences over 12 months), $OP12D(t+i)$, and the current Japanese CPI (also log differences over 12 months), which I denote $P12D(t)$. The sample period is January 1977 - May 1995. The cross correlation between lagged $OP12D$ and current $P12D$ is generally strongly positive, reaching its peak at $i = -10$ months, at 0.665. Therefore, there is good reason to suspect that the Bank of Japan is paying close attention to the oil price index. In fact, the cross correlation between $OP12D(t+i)$ and $R(t)$ (its level) is also high: it reaches the peak at $i = -10$ as well, at 0.603. This seems to indicate that the Bank of Japan is responding sensitively to OP, raising R to prevent excessive inflation whenever it sees an increase in this variable. Hence, if the interpretation of the price puzzle problem given by Sims (1992) is correct, it is expected that an inclusion of this variable helps resolve the problem.

This impression is further strengthened by Figure 1. First, I estimated a standard VAR model with four variables, P , Y , R and M . They are orthogonalized in the order of P - Y - R - M . The sample period is February 1977 - May 1995, and the number of lags was set to thirteen. In all the equations the seasonal dummies and a dummy variable to account for the effects of the introduction of the new national consumption tax (April 1989) were included. In the left panel of Figure 1, I show the response of P to one standard deviation shock to R , together with one and two standard error bands based on 1,000 draws. The estimate suffers from a typical "price puzzle" problem: in response to an increase in R , P increases strongly and positively. Results from the variance decomposition indicated that shocks to R account for 49.25% of the forecast error variance of P at the 24 months horizon. Next, I estimated a VAR model that includes all the variables used in the previous estimation plus OP. OP is put before P in the recursive ordering. The estimated response of P to an R shock in this model is presented in the right panel of Figure 1. The response has become clearly weaker due to the introduction of OP. Using the one standard error bands as the main reference point (see below), in the left panel, the response is significantly positive for 35 months. In the right panel, the response turns insignificant after 18 months. Hence, the inclusion of OP does not resolve the price puzzle problem entirely, but it goes a long way toward it. I conclude that the inclusion of OP is essential to a correct identification of monetary policy shocks. Kim and Roubini (1996) include OP in their multi-country analysis due to a similar consideration.

Unlike Kim and Roubini, however, I introduce the current and lagged values of OP into the model as exogenous variables. That is, OP enters in all the equations for the other eight variables, but the dynamics of OP is independent of the others. This seems to be a reasonable assumption, as OP is determined

in the world commodity market (note that it is quoted in US Dollars) where the presence of Japan is not that vital. OP seems to be affected mainly by sources that are exogenous to Japan, such as political considerations among OPEC countries. As it is out of the interest of the paper, I omit the equation that explains the movement of OP from the model. With this assumption, my model becomes a structural VARX model. This treatment does not reduce the number of variables per equation, but it does reduce the number of equations from nine to eight and thus lowers the computational burden for the estimation.

Another novel feature of the model is the inclusion of SPEND and ORDER. SPEND is a monthly series that is often used as a proxy for consumption. ORDER is often used as a proxy for equipment investment⁴. Normally, in the literature, only industrial production, Y, is included as a proxy for the amount of transaction in the economy. It serves as an "instrument" for the demand for monetary aggregates. But I found that Y alone was not a sufficient proxy in Japan: when I did not include SPEND and ORDER, innovations in Y were found to be only weakly correlated with those of H and M. Hence, I include the two variables as additional indicators of amount of transaction in the economy. This also serves to strengthen the identification restriction to distinguish demand and supply behaviors in the financial market. Also, as a by-product, we can study if monetary policy affects output mainly through consumption or investment.

5 Two Models of Japanese Monetary Policy

I estimate two versions of a VARX model with eight endogenous variables, ordered as P-SPEND-ORDER-Y-R-M-H-BL, that differ only in their specifications of the short run structure. The two models, in fact, differ only in their specification of the policy equation. In one of the models, the central bank is assumed to intervene in the market for high powered money. I will call this the H model. In the alternative model, the central bank is assumed to intervene in the market for BL. This model will be called the BL model.

Here, I explain their short run structure briefly. The two models can be nested by a more general model, which has one more free parameter than either of the two. Table 1 represents this nested model, in the form of equation 3 in the previous section. In this table subscript "S" stands for "SPEND" and "O" stands

⁴To check the validity of this convention, I transformed SPEND and ORDER into quarterly series and estimated correlations between growth rates of those variables and those of real consumption and real equipment investment from the National Accounts. The growth rates were defined as the log differences from the same quarter of the previous year, and the estimation period was from the first quarter of 1977 to the second quarter of 1995. The correlation between SPEND (deflated by P) and real consumption was 0.78, while the correlation between ORDER and real equipment investment was 0.61.

for "ORDER". Also, "u's" are residuals from the first stage OLS estimation and "e's" are structural shocks. The large matrix on the right hand side corresponds to the matrix $I - \Gamma_0$. All the "a's" inside the matrix are free parameters. Note that I am normalizing the diagonal terms in the matrix Γ_0 in equation 2 to be one. As a consequence, all the diagonal terms inside the matrix of the right hand side of Table 1 are equal to zero. I also assume that the variance-covariance matrix for the structural shocks, Σ_ϵ , is a diagonal matrix.

Table 1: Short Run Structure of the Nested Model

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

The first thing I did was to divide the model economy into two sectors, the non-financial sector, which is the (P,SPEND,ORDER,Y) block, and the financial sector, which is the (R,M,H,BL) block. I assume that the economy has a short-run block recursive structure: the non-financial sector variables do not respond contemporaneously to innovations in the financial sector variables. Similar assumptions are often made in the literature (Gordon and Leeper (1994), etc.). The justification is that the non-financial sector responds only slowly to changes in R because of decision lags. This assumption means that the matrix for the contemporaneous relationship between innovations, $I - \Gamma_0$ in equation 3, becomes block-triangular, with no feedback from the lower part of u to its upper part. Because I am not so much interested in modeling the structure of the non-financial sector in this paper, I simply impose a lower triangular structure on the upper part of the matrix $I - \Gamma_0$. This does not affect the estimation results for the financial-sector part of the model, nor the responses of non-financial variables to shocks to the financial sector.

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, ordered in this way. The (CB) equation describes the behavior of the central bank. The bank chooses the optimal combination of (R,H) or (R,BL), depending on the model, after observing the value of its intermediate target, M. The private non-financial variables, P, SPEND, ORDER and Y, are excluded from

this equation because the central bank receives information on those variables only with lags. This type of identification restrictions has become quite common since Sims (1986) and has turned out to be quite useful. In the (MD) equation I follow convention and assume that money demand depends on the amount of nominal transaction, captured by P , $SPEND$, $ORDER$, and Y , and the interest rate. The (HD) equation is an equation for the demand for high powered money. It describes how the private economy, given the amount of total money stock (M), determines allocation between its more liquid components (H) and less liquid components. The (BLD) equation is an equation for the demand for BL , which describes the behavior of the banking sector, and it reflects all the variables in the model. Excluding BL from the M demand and the H demand equations reflects the assumption that, in the short run, shocks to the banking sector do not directly affect consumers and firms⁵.

Note that I am using only the exclusion restrictions of the four variables representing the amount of transaction, P , $SPEND$, $ORDER$ and Y , from the (CB) equation to separately identify supply and demand side behaviors in the financial sector. Hence, it becomes crucial that those variables are good proxies for the amount of transaction, or, in other words, that their innovations are reasonably highly correlated with those of monetary aggregates.

The H model and the BL model are obtained by adding just one more restriction to the above nested model. In the H model, the central bank is supposed to control H and not BL , so BL is excluded from the central bank equation: $a_{5BL} = 0$. The central bank just lets the demand side determine the quantity of BL . Note that this additional restriction makes the financial sector of the model block recursive, in that R , M and H are determined independently of BL . On the other hand, in the BL model, the central bank controls BL and not H , so H is excluded from the central bank equation: $a_{5H} = 0$. The central bank just lets the demand side determine the quantity of H . Both models are overidentified by two extra restrictions. I also estimated the above nested model.

Theoretically speaking, if the H model is the right model, we would expect a_{5H} to be non-negative, that is, the supply curve of high powered money should be upward sloping in the (R, H) plane. On the other hand, if the BL model is the right model, the argument in section 2-3 suggests that a_{5BL} should be non-positive and a_{8R} should be positive. That is, in the (R, BL) plane, the supply curve for BL should be downward sloping, while the demand curve should be

⁵I tried changing the order between M , H and BL in the matrix (while fixing the list of variables included in the CB equation), and found that the results were always quite similar. The only change was in the variance decomposition: relative contribution of the MD and the HD shocks changed across specifications. The contribution of the CB shock, which is of the greatest concern to this paper, was not sensitive to the changes.

upward sloping. In both cases, a_{5M} is expected to be positive, or, when the central bank sees an increase in M , it tries to tighten its stance.

6 Results

First Stage Estimation

I estimated the VARX model with the eight endogenous variables mentioned above and the current and lagged values of OP as exogenous variables. For the lagged OP, I always used the same lag structure as that for the lagged endogenous variables. The sample period was February 1977 — May 1995. I also included the seasonal dummies and a dummy variable for the introduction of the new consumption tax (April 1989).

Throughout the analysis, I follow the recent convention in the literature and use **levels**, rather than first differences, for all the series. As Bernanke and Mihov (1996) argue, a levels specification yields consistent estimates whether cointegration exists or not, but a difference specification is inconsistent if some variables are cointegrated.

Using the Likelihood Ratio Test of Sims (1980) I determined that the lag length had to be at least 13 (12 was rejected in favor of 13, and 11 was rejected in favor of 12). This is probably due to the presence of seasonality in some of the variables which cannot be fully taken out by the introduction of the seasonal dummies⁶. Use of 13 lags would leave the degree of freedom in each regression to be only 78, far less than half of the sample size (220). Instead, I decided to use the lag structure (1, 2, 3, 6, 9, 12, 13). A similar approach is used in Bernanke and Mihov (1996) and Clarida and Gertler (1996). I tested this structure against more general structures such as (1-13), (1-9, 12,13), and (1-6, 9, 12, 13), and my proposed lag structure was never rejected. Using this structure increases the degrees of freedom in each regression to 142, slightly less than two thirds of the sample size.

Correlation across Residuals

The correlation matrix for the residuals from the first stage of the estimation is shown in Table 2. The diagonal terms are their standard deviations. “***” means that the correlation is significantly different from zero at the 5% level, “**” means that it is significant at the 10% level, and “+” means that it is significant at the 15% level.

⁶When the seasonality exists for the growth rate, rather than for the level, inclusion of the 13th lag could become essential.

Table 2: Standard Deviations and Correlations Across Residuals

	P	SPEND	ORDER	Y	R	M	H	BL
P	0.003	0.001	-0.016	0.065	0.040	-0.013	0.103*	-0.041
SPEND		0.012	0.087*	-0.035	0.096*	0.014	0.106*	0.039
ORDER			0.006	0.073 ⁺	-0.056	0.082 ⁺	-0.042	-0.023
Y				0.009	0.030	0.086 ⁺	-0.134**	-0.064
R					0.002	0.019	0.033	0.017
M						0.002	0.269**	-0.105*
H							0.006	-0.090*
BL								0.021

Note: The diagonal terms are standard deviations.

Contemporaneous Relationship

The matrix of the contemporaneous relationship, $I - \Gamma_0$ in equation 3, is estimated using the procedure OPTMUM of GAUSS386. I started the estimation using the BFGS algorithm. I switched to the Newton-Raphson algorithm as the procedure got close to convergence⁷. Table 3 presents the result for the nested model, Table 4 for the H-model, and Table 5 for the BL model. To save space, only the lower part of the matrix Γ_0 , that is, the financial sector part, is shown. The full result, as well as the standard errors around the point estimates are summarized in Appendix B. Superscripts "*" and "**" indicate that a point estimate is more than one and two standard error(s) away from zero, respectively. The standard errors were calculated from the inverse of the Hessian of the Log Likelihood, analytically derived. The tables also show standard deviations of the structural shocks (the vector ϵ_t in equation 3) at the end of each equation in parentheses.

The overidentification restrictions were not rejected in any of the cases. The p-values for the nested, the H and the BL models were 32.56%, 57.76% and 61.33%, respectively.

⁷A potential problem is that the log likelihood function may have multiple local maxima. If a researcher uses only one set of initial values for this iterative procedure, there is a fair chance that the resulting estimates do not represent the global maximum of the log likelihood function. This problem is present, for example, when one uses the pre packaged program in RATS, which always uses -0.1 as initial values for all the free parameters. My solution is to try many sets of initial values, picked by a random number generator. When multiple peaks are present, I pick the estimates that correspond to the highest value of the log likelihood.

Table 3: Contemporaneous Relationship: *the nested model*

(CB)	$u_R = 5.4 \cdot u_M + 0.29 \cdot u_H + 0.56 \cdot u_{BL} + e_{CB} \quad (0.014)$
(MD)	$u_M = 0.098 \cdot u_P + 0.070 \cdot u_{SPEND} - 0.068 \cdot u_{ORDER} + 0.046 \cdot u_Y$ $- 3.6 \cdot u_R + e_{MD} \quad (0.0080)$
(HD)	$u_H = 0.25^* \cdot u_P + 0.049^* \cdot u_{SPEND} - 0.065 \cdot u_{ORDER} - 0.10^* \cdot u_Y$ $- 0.0081 \cdot u_R + 1.2 \cdot u_M + e_{HD} \quad (0.0053)$
(BLD)	$u_{BL} = -0.083 \cdot u_P + 0.091 \cdot u_{SPEND} - 0.46 \cdot u_{ORDER} - 0.32 \cdot u_Y$ $- 2.7 \cdot u_R + 15 \cdot u_M + 0.13 \cdot u_H + e_{BLD} \quad (0.034)$

In Table 3, estimates for the nested model are summarized. Unfortunately, standard errors around the estimates are large for most of the free parameters. Still, it can already be seen that the estimates are inconsistent with the theoretical BL model: theory suggests that in the central bank equation R should depend negatively on BL, and in the BL demand equation R should depend positively on BL. The estimates are the other way round.

Table 4: Contemporaneous Relationship: *the H model*

(CB)	$u_R = 2.4 \cdot u_M + 0.44 \cdot u_H + e_{CB} \quad (0.0057)$
(MD)	$u_M = 0.044 \cdot u_P + 0.036 \cdot u_{SPEND} - 0.023 \cdot u_{ORDER} + 0.030 \cdot u_Y$ $- 1.8 \cdot u_R + e_{MD} \quad (0.0042)$
(HD)	$u_H = 0.28^* \cdot u_P + 0.055^* \cdot u_{SPEND} - 0.098^* \cdot u_{ORDER} - 0.11^{**} \cdot u_Y$ $- 0.41 \cdot u_R + 2.3^{**} \cdot u_M + e_{HD} \quad (0.0058)$
(BLD)	$u_{BL} = -0.25 \cdot u_P + 0.081 \cdot u_{SPEND} - 0.66 \cdot u_{ORDER} - 0.14 \cdot u_Y$ $+ 0.18 \cdot u_R - 0.96^* \cdot u_M - 0.29^* \cdot u_H + e_{BLD} \quad (0.020)$

Table 4 reports results for the H model, where the coefficient on BL in the (CB) equation is restricted to be zero. The likelihood ratio test that tested this model against the nested model did not reject this additional restriction: the p-value was 71.68%. The standard errors are still not small, except for those in the HD equation. But at least the point estimates are consistent with theory. In the (CB) equation, R depends positively on both M and H: in other words, the "supply curve" for H is upward sloping in the (R,H) plane, and it shifts upwards when the central bank observes an increase in M. Hence, the estimates support the "partial accommodation" view of monetary policy rule. Demands for both M

and H depend negatively on R. Demand for M generally depends positively on the amount of transaction, except for the case of ORDER. The coefficients in the (HD) equation are quite interesting. First, it depends positively on the demand for a broader monetary aggregate (M), as expected. It also depends positively on P and SPEND, as expected. On the other hand, it depends negatively on ORDER and Y. A message one could get from these results is the following. Consumption tends to require use of medium of exchange with greater liquidity, such as cash. Other activities, such as equipment investment, probably involves use of less liquid medium of exchange, such as demand deposits. Hence, given the total amount of medium of exchange (M), when the amount of transaction for the consumption purpose goes up, demand for more liquid assets, namely H, increases. When the amount of transaction for other purposes goes up (again given the total amount of M), the private sector tends to increase demand for medium of exchange with less liquidity, and therefore the demand for H decreases.

Table 5: Contemporaneous Relationship: *the BL model*

(CB)	$u_R = 11.2 \cdot u_M + 1.61 \cdot u_{BL} + e_{CB} \quad (0.037)$
(MD)	$u_M = 0.27 \cdot u_P + 0.18 \cdot u_{SPEND} - 0.21 \cdot u_{ORDER} + 0.094 \cdot u_Y$ $- 9.2 \cdot u_R + e_{MD} \quad (0.020)$
(HD)	$u_H = 0.24^* \cdot u_P + 0.048^* \cdot u_{SPEND} - 0.046 \cdot u_{ORDER} - 0.091^{**} \cdot u_Y$ $+ 0.080 \cdot u_R + 0.45 \cdot u_M + e_{HD} \quad (0.0054)$
(BLD)	$u_{BL} = 0.44 \cdot u_P + 0.15 \cdot u_{SPEND} - 0.75 \cdot u_{ORDER} - 0.65 \cdot u_Y$ $- 1.8 \cdot u_R + 26 \cdot u_M + -1.6 \cdot u_H + e_{BLD} \quad (0.048)$

Table 5 presents results for the BL model, in which H is excluded from the (CB) equation. I found that, in this case, the likelihood function has multiple peaks that correspond to very different sets of parameter values. I simply report the case where the likelihood value turned out to be the highest. Sets of parameter values that corresponded to lower peaks all showed some kind of puzzling results, such as money supply going up in response to a tight money shock. In the case reported in the table, the BL model was not rejected against the nested model by the Likelihood Ratio test: the p-value was 91.46%. The standard errors are huge, as can be seen in Appendix B. There is a clear problem with those estimates. According to the theory proposed by the supporters of the BL model, the supply curve for BL should be a downward sloping curve in the (R,BL) plane, while the demand curve should be upward sloping. The estimation results are the other way round. This poses a fundamental doubt on the relevance of the BL model.

Impulse Responses

Although I consider Table 5 as sufficient evidence to disqualify the BL model, I will briefly compare estimated impulse response functions from the two models. Figure 2 shows estimated impulse responses to a shock to the central bank equation (e_{CB}) for the H model, together with their one and two standard error bands based on 10,000 draws. Figure 3 shows those for the BL model. Those are responses to a one standard deviation increase in e_{CB} . As this increases R initially, it should be considered as a tightening of policy stance. I follow Sims and Zha (1995) in using the one standard error bands as the main reference point. As they argue, since VAR models do not impose many arbitrary restrictions on parameters, they tend to have large standard errors, and therefore use of the conventional two standard errors as the main reference point seems too strict. Hence, in this paper when I mention significance of responses, it is with respect to the one standard error bands.

Responses of financial variables (M , H , R and BL) for the H model in Figure 2 show patterns that are consistent with prior briefs about monetary policy: R goes up significantly for a few months (**liquidity effect**), and then turns significantly negative, as the Fisher effect (the expected deflation effect) starts to dominate. On the other hand, M and H decrease strongly significantly, and the effects are long lasting. The response of BL alternates signs over time, but, as the H-model has no predictions on how BL is determined, this is not inconsistent with the theory.

On the other hand, the responses for the BL model in Figure 3 continue to show problems. In response to a tightening in the policy stance, BL goes down, not up, initially very strongly. This pattern is inconsistent with the views of the proponents of the BL model. Hence, I conclude that the BL model is an inappropriate model⁸. The rest of the analysis focuses on the H model.

Going back to Figure 2, the first panel shows that a tightening of the policy stance does not have an immediate impact on P , and then P starts to decrease after nearly two years. In the long run, the negative effect turns marginally significant. In that sense, **this model does not suffer from the price puzzle**. This slow response of P is similar to the one reported for the US by various authors⁹ except that the slowness of the response is more pronounced in the case of Japan. Responses of $SPEND$, $ORDER$ and Y all have expected negative signs and are significant, except for the brief spike in the response of $SPEND$ at the thirteenth month, which is presumably due to remaining seasonality in this series.

⁸It should be also noted that the response of P indicates a typical "price puzzle" problem.

⁹In particular, Christiano, Eichenbaum and Evans (1996) used this result to conclude that the nominal wage setting model and the Lucas misperception model are unrealistic because they both predict an immediate decrease of P in response to a tight money shock

Note that the response of SPEND does not become systematically significantly negative until after 17 months, while that of ORDER turns significantly negative after four months (though it turns insignificant after 40 months). Moreover, the latter response is larger than the former in magnitude: note that I had divided ORDER by 10 for computational convenience. Hence, to get the true effect on ORDER the responses have to be multiplied by ten. Those facts are consistent with the standard belief that monetary policy works primarily through affecting investment, though it is not necessarily consistent with the results of Yoshikawa (1996) for Japan and Tachibana (1996) for the US (though it is important to keep in mind that my approach is very different from theirs, and so a direct comparison is difficult). Presumably due to the effect on ORDER, the response of Y turns significantly negative very quickly and stays negative until the 40th month.

Variance Decomposition (the H model)

Table 6 shows results of variance decomposition for the H model. Table 6-1 shows contributions of the four financial sector shocks (shocks to the CB, MD, HD, and BLD equations) to the financial sector variables, R, M, H, and BL, within one month (the impact effects). Note that those shocks have no effects on non-financial sector variables, P, SPEND, ORDER, and Y, within one month, by assumption. Table 6-2 shows contributions of policy shocks (e_{CB}) to forecast variance for the eight variables at time horizons of the twenty fourth month and the forty eighth month¹⁰.

Table 6-1: Variance Decomposition (the H model)
for WITHIN ONE MONTH, in %

shock \ Var.	R	M	H	BL
CB	12.59	68.63	38.05	1.46
MD	83.33	16.59	1.70	0.06
HD	2.52	13.75	56.21	0.08
BLD	-	-	-	97.68

Table 6-2: Variance Decomposition (the H model):
Contribution of Policy Shocks, in %

	P	SPEND	ORDER	Y	R	M	H	BL
24 months	1.29	7.70	20.12	36.76	21.31	68.03	53.99	7.00
48 months	13.21	23.75	26.74	44.71	25.57	64.19	58.54	13.65

From Table 6-1 we learn the following:

¹⁰In both tables, I computed those contributions so that the sum of relative contributions of the eight structural shocks is equal to 100%. Therefore, they are contributions to the variances that remain after taking away the effects of oil prices.

- (1) policy shocks primarily affect monetary aggregates, namely M and H, in the short run, but they also have important effects on R in the short run,
- (2) demand shocks also have important effects on both R and monetary aggregates (M and H),
- (3) therefore, from (1) and (2), one can conclude that it is important to take into account the possibility of R and monetary aggregates being determined simultaneously by demand and supply in the financial sector, and
- (4) policy shocks have unimportant effects on BL in the short run.

Relative contributions of policy shocks in the medium to long runs in Table 6-2 confirm the impressions we got from the impulse response analysis:

- (5) effects of policy on P becomes sizable only in the long run,
- (6) effects on ORDER and Y show up quickly while that on SPEND increases only slowly,
- (7) in the medium to long runs, monetary policy has strong effects on quantities, that is, SPEND, ORDER, and Y, and smaller (but still important) effects on P, and
- (8) policy shocks have long lasting large effects on M and H, and effects on R also continue to be sizable. Their effect on BL grows in the long run.

7 Conclusions

Important conclusions from this study are as follows. First, the H model is a better model to describe Japanese monetary policy than the BL model. The BL model performs as well as the H model does in the likelihood value sense, but its estimates do not make economic sense because some of the coefficients and impulse responses turn out to be contradictory to what the proponents of the model claim. Hence, it seems more appropriate to assume that the amount of BL is demand determined in the short run: the composition of different methods of supplying H is probably determined by some institutional factors of minor significance within the financial sector. Second, it is important to allow for the possibility that the central bank is following a partially accommodating rule. My estimates show that both demand and supply shocks have important effects on both monetary aggregates and the interest rate in the short run. Third, the estimated policy shocks do not suffer from the liquidity puzzle nor the price

puzzle. They can thus be considered as a reliable indicator of autonomous policy changes. Finally, policy shocks thus estimated have quick and long lasting strong effects on quantities (SPEND, ORDER and Y, though the effect on SPEND shows up only in the medium run) and their effect on the price level turns sizable only in the long run.

Appendix

A Data Source

OP: Spot US\$ per Barrel World ZA, International Financial Statistics, code 001 76 AAZ.

SPEND: Living Expenditure (All Households), in Yen, Nikkei NEEDS data set, code KYAA039.

ORDER: Net New Orders, Total excluding ships, S.A., Billion yen, OECD Main Economic Indicator, code 46319910.

Y: Indexes of Industrial Production (1990 average=100), seasonally adjusted, from OECD, Main Economic Indicators, code 46205112.

P: Consumer Price Index (All Japan), General, excluding imputed rent (1990 = 100), the middle period of each month, from International Financial Statistics, IMF, code 158 64.

R: Call Rates, Collateral and Unconditional (Central Rate, Monthly average, interest per annum, %), Economic Statistics Annual, the Bank of Japan.

M: M2+CD, average outstanding, seasonally adjusted, from the Bank of Japan Home Page.

H: Monetary Base, average outstanding, adjusted for the reserve requirement ratio changes, seasonally adjusted, from the Bank of Japan Home Page.

BL: Loans and Discounts (end of month), Bank of Japan Accounts, in 100 million yen, from Economics Statistics Monthly, the Bank of Japan.

B Full Results: Contemporaneous Relationship

This section reports full results for the estimated contemporaneous relationship in section 6.2. In the table, "nest", "H", and "BL" mean estimation results for the nested model, the H model, and the BL model, respectively.

	nest	H	BL		nest	H	BL
a_{2P}	0.004 (0.294)			a_{7P}	0.254 (0.160)	0.279 (0.149)	0.243 (0.137)
a_{3P}	-0.035 (0.146)			a_{7S}	0.049 (0.033)	0.055 (0.037)	0.048 (0.032)
a_{3S}	0.044 (0.033)			a_{7O}	0.065 (0.147)	-0.098 (0.073)	-0.046 (0.067)
a_{4P}	0.229 (0.225)			a_{7Y}	-0.102 (0.077)	-0.115 (0.045)	-0.091 (0.042)
a_{4S}	-0.033 (0.050)			a_{7R}	-0.008 (1.103)	-0.412 (0.884)	0.080 (0.615)
a_{4O}	0.119 (0.101)			a_{7M}	1.229 (5.006)	2.290 (0.968)	0.450 (0.967)
a_{5M}	5.388 (30.87)	2.449 (4.930)	11.15 (113.0)	a_{8P}	-0.083 (2.679)	-0.245 (0.515)	0.438 (2.281)
a_{5H}	0.295 (1.584)	0.439 (0.710)	- -	a_{8S}	0.091 (0.405)	0.081 (0.115)	0.145 (0.675)
a_{5BL}	0.560 (4.431)	- -	1.614 (15.93)	a_{8O}	-0.460 (2.085)	-0.066 (0.231)	-0.749 (1.524)
a_{6P}	0.098 (0.750)	0.044 (0.156)	0.270 (4.901)	a_{8Y}	-0.321 (1.744)	-0.144 (0.151)	-0.647 (1.036)
a_{6S}	0.070 (0.451)	0.036 (0.075)	0.176 (3.029)	a_{8R}	-2.742 (14.28)	0.178 (0.617)	-1.834 (29.15)
a_{6O}	-0.068 (0.594)	-0.023 (0.104)	-0.207 (3.967)	a_{8M}	14.77 (80.13)	-0.963 (0.841)	26.14 (42.84)
a_{6Y}	0.046 (0.211)	0.030 (0.044)	0.094 (1.374)	a_{8H}	0.133 (6.625)	-0.292 (0.252)	-1.626 (4.374)
a_{6R}	-3.569 (23.58)	-1.789 (3.711)	-9.154 (158.9)				

Standard errors are in parentheses. Results for the non-financial sector for the H model and the BL model are identical to those of the nested model and are therefore omitted.

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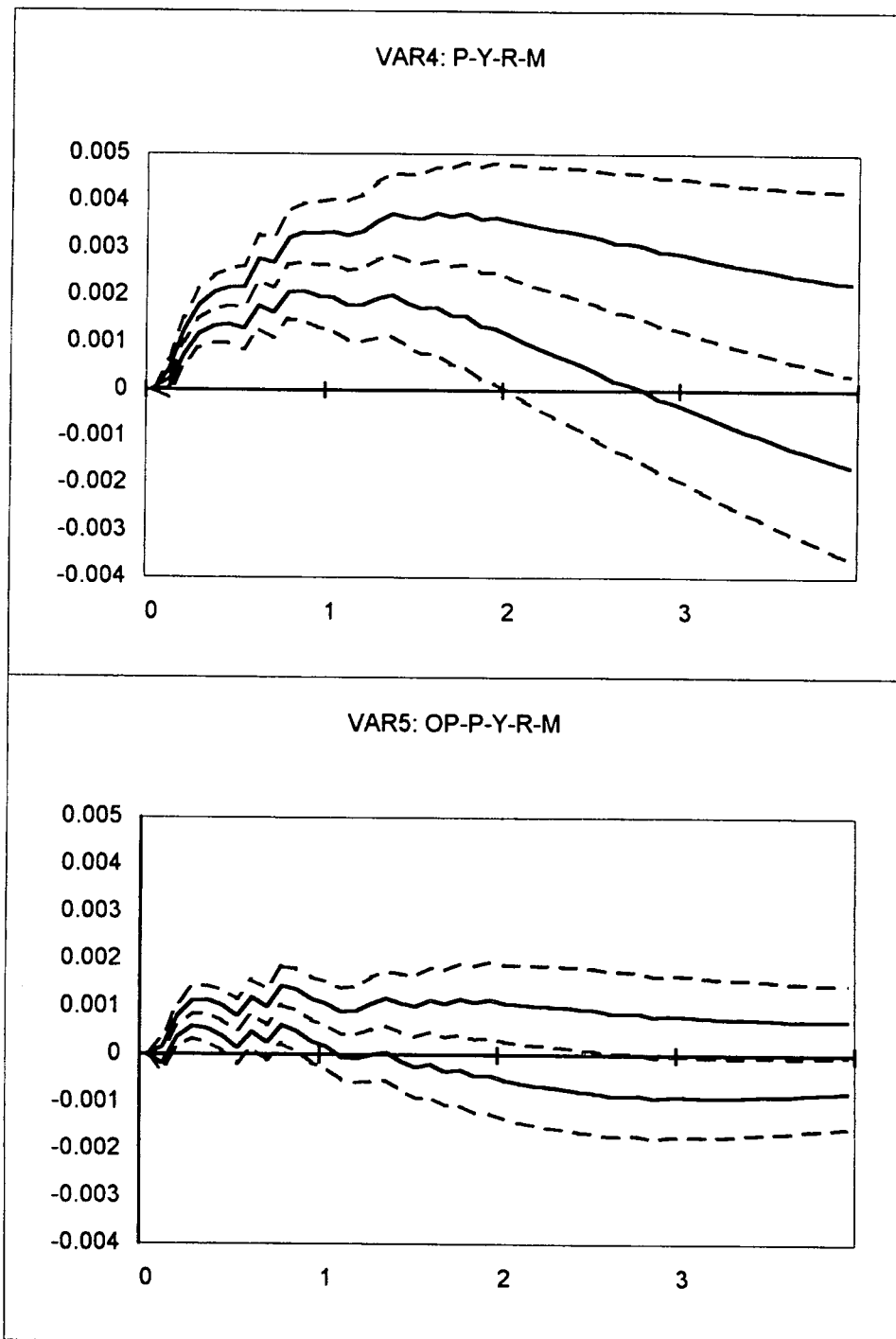
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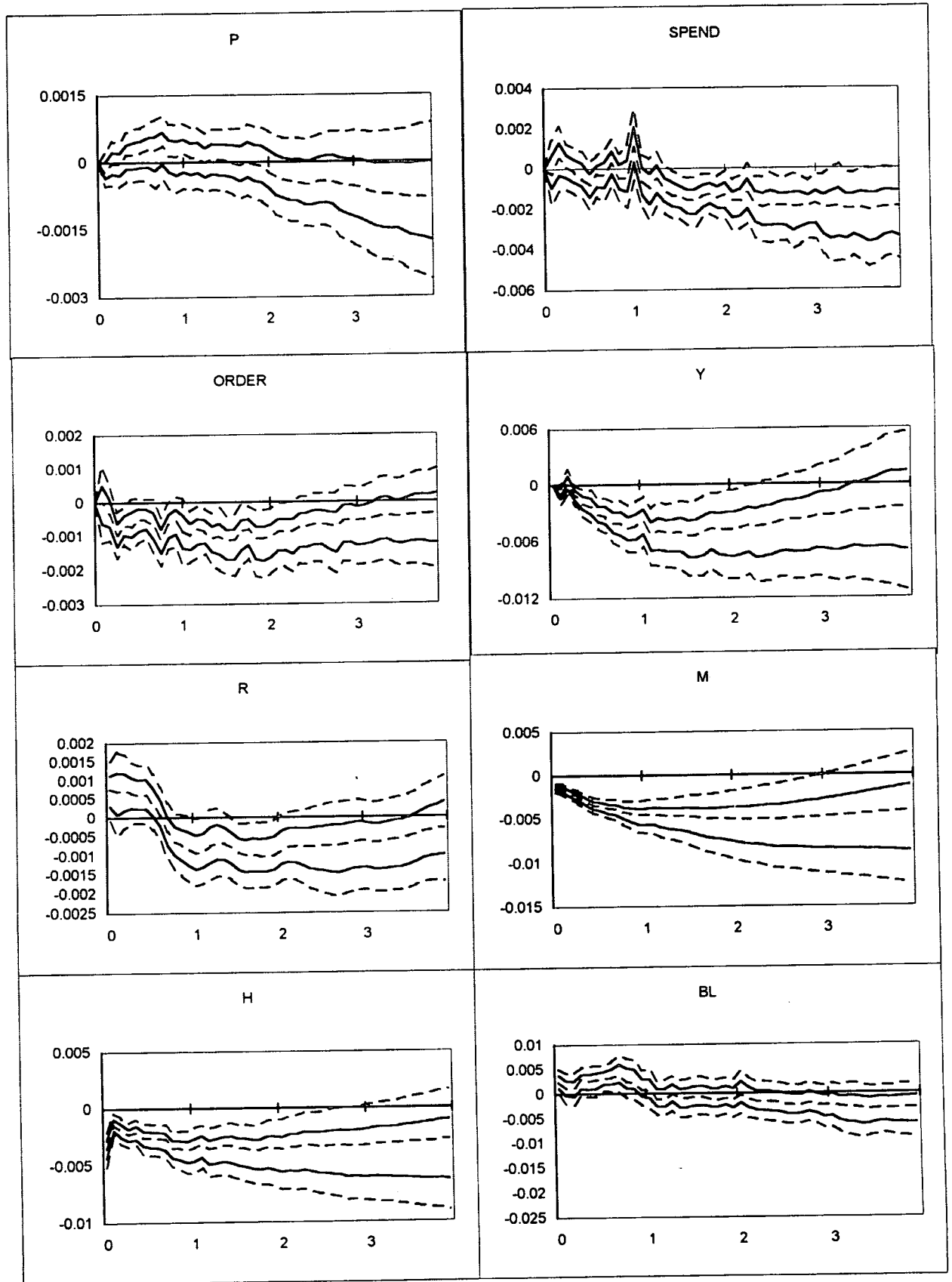
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Figure 1: Responses of P to One Standard Deviation R Shock



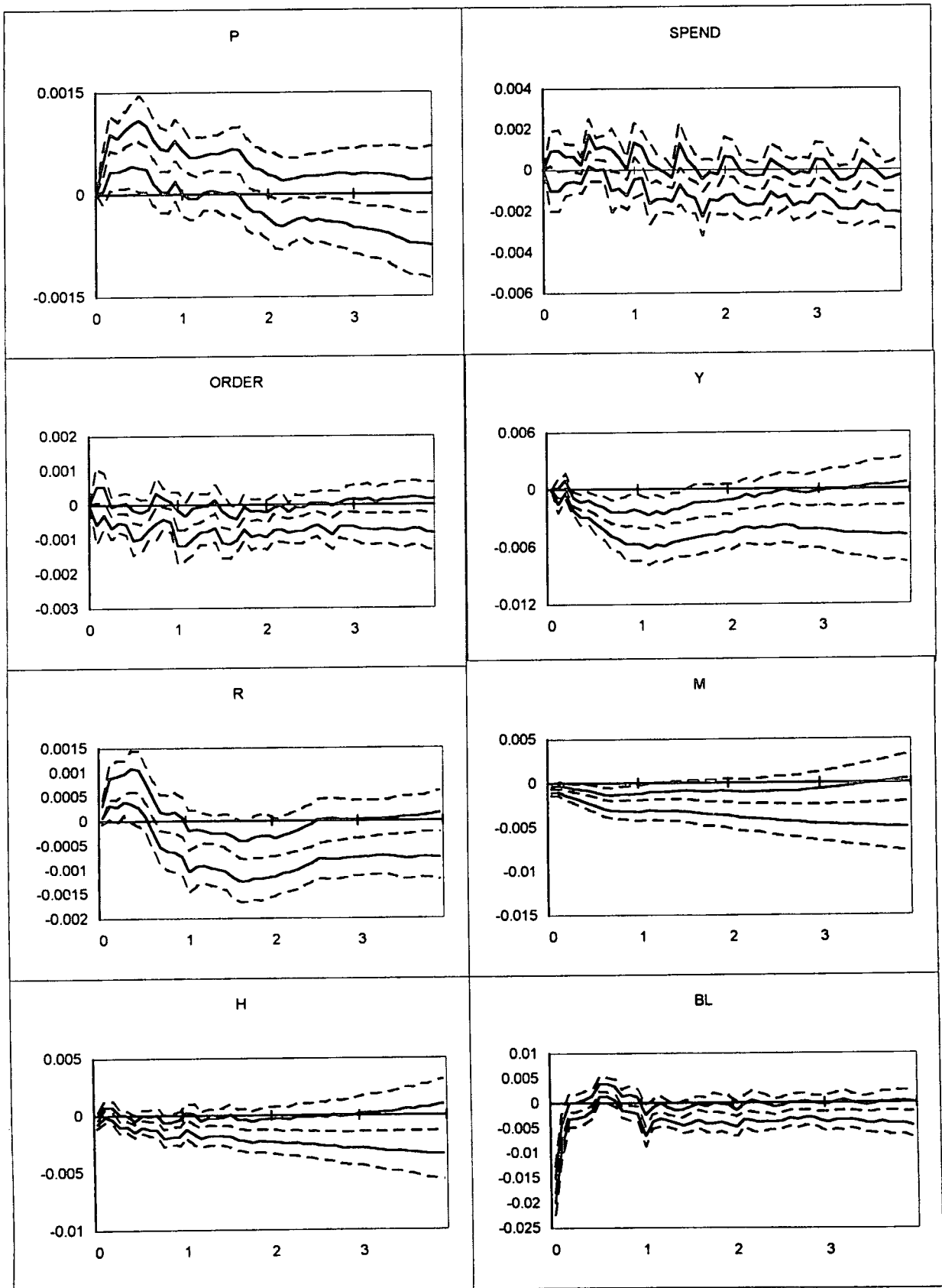
unit on the horizontal axis: years

Figure 2: Responses to One Standard Deviation Policy Shock: the H model



units on the horizontal axis: years

Figure 3: Responses to One Standard Deviation Policy Shock: the BL model



units on the horizontal axis: years

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