Economic Review

Federal Reserve Bank of San Francisco

1993 Number 3

Money, Interest Rates and Economic Activity: Stylized Facts for Japan

Ramon Moreno and Sun Bae Kim

Economists, Federal Reserve Bank of San Francisco.

The authors thank the Editorial Committee, comprising Chan Huh, Elizabeth Laderman, and Bharat Trehan, for many helpful comments. We also thank Greg Holmes and Jacob Pozharny for research assistance.

This paper examines how financial market changes affect the usefulness of two alternative indicators of monetary policy in Japan, a monetary aggregate and an interest rate. The paper tests whether these variables are good predictors of output, and whether responses to shocks to these variables broadly conform to the implications of the monetary transmission model, over two periods between 1960 and 1992. In the earlier period when Japan's financial markets were less developed, a monetary aggregate (M2 + CDs) is a relatively useful indicator of monetary policy whereas an interest rate variable is not. In particular, we find some evidence of a "liquidity effect" in response to innovations in money. Neither variable is an entirely satisfactory indicator of monetary policy in the second sample. The results suggest that financial market development may have contributed to reducing the usefulness of money as an indicator of monetary policy.

Are monetary policy innovations better represented by shocks to money or to interest rates? In order to resolve this question, researchers have used vector autoregression (VAR) models to attempt to ascertain whether responses to innovations in either variable satisfy two criteria. First, changes or innovations in monetary policy should be good predictors of real economic activity. Second, the qualitative effects of monetary policy innovations should conform to those predicted by the traditional monetary transmission model; namely, in the short run, an expansionary policy leads to an excess supply of money because of output and price rigidities. In response to this excess supply, nominal and real interest rates fall. This "liquidity effect" is a key element in the monetary transmission mechanism which ultimately leads to an increase in real output.

The empirical evidence is ambiguous. Research applying VAR models to U.S. data generally concludes that interest rates are better predictors of real output than are monetary aggregates.[1] However, responses to shocks to either money or interest rates are not entirely consistent with the monetary transmission model. For example, some impulse response analyses reveal that while a positive monetary aggregate shock is associated with increases in the price level, it is also associated with an *increase* in interest rates, or no liquidity effect (Sims 1986, Leeper and Gordon 1992), and a *contraction* in output (Sims 1986). The last two responses do not correspond to the monetary transmission model.[2] Furthermore, while an interest rate innovation is associated with declines in money and output, as would be expected, it is also associated with an *increase* in the price level, a result that contradicts the monetary transmission model (Sims 1986).

---

1. See, for example, Sims (1980) and Bernanke and Blinder (1992). An exception is Strongin (1992) which focuses on a special representation of a very narrow monetary aggregate.

2. However, recent research indicates that a liquidity effect can be found in U.S. data if a narrower monetary aggregate is used that takes some of the subtleties of Fed operating procedure into account (Eichenbaum 1992, Christiano and Eichenbaum 1992, and Strongin 1992). While Eichenbaum (1992) finds a liquidity effect using a nonborrowed reserves aggregate, this measure is not entirely successful because real output declines in response to innovations in nonborrowed reserves. Strongin (1992) uses the ratio of nonborrowed reserves to total reserves as an indicator of policy innovations, and a recursive ordering that appears to successfully reflect Fed operating procedure. His indicator satisfies the two criteria outlined in the text.

Research applying VAR models to Japanese data also has yielded ambiguous results. For example, Suzuki, Kuroda, and Shirakawa (1988) find that a broad monetary aggregate, M2 + CDs, is a good predictor of Japanese real GNP.[3] However, the dynamic responses to money shocks presented in Sims (1992) do not conform to the transmission model. As in the U.S., the response to a money shock reveals the absence of the "liquidity" effect in Japan, as well as a contraction in output. Japanese data also yield the "price puzzle" of an interest rate innovation leading to a price increase.

Two explanations may be offered for why VAR models have failed to identify an unambiguous indicator of monetary policy in the U.S. or in Japan. First, the studies cited in this paper generally rely on a recursive identification procedure to distinguish between innovations in money or interest rates. Under certain conditions, innovations identified using such a procedure will not successfully distinguish monetary policy shocks from real shocks to aggregate supply or shocks to money demand. Difficulties in isolating shocks are particularly likely if monetary authorities do not consistently target a monetary aggregate or an interest rate. Second, developments in financial markets may influence the ability to identify a policy indicator. For example, even if the authorities consistently target a monetary aggregate, demand shocks may still cause short-term fluctuations in monetary aggregates if deregulation and innovations in financial markets weaken the central bank's effectiveness in controlling the monetary aggregate target. In fact, the choice of target itself may shift as a result of significant changes in financial markets.

Japan provides a potentially illuminating case study to ascertain the plausibility of the second explanation. Up to the early 1980s, securities markets were undeveloped and commercial banks were heavily dependent on the Bank of Japan (BOJ), which used both market and nonmarket instruments to achieve a credit target. Subsequent deregulation and innovations in financial markets have reduced the dependence of commercial banks on the BOJ. As a result, the BOJ has relied more heavily on market instruments for monetary control, and has paid attention to both monetary aggregates and interest rates.

The primary aim of this paper is to explore the implications of financial market changes for the identification of monetary policy innovations in Japan. We do this by estimating a four-variable VAR model of the Japanese economy similar to the models estimated by Sims (1980, 1992) over two sample periods: the first, 1960–1980, when securities markets were undeveloped and the BOJ wielded much greater direct influence on commercial banks in implementing monetary policy, and the second, 1981–1992, when Japan's financial markets became more developed, the dependence of banks on the BOJ declined, and the BOJ began to rely more heavily on market-based mechanisms for monetary control.

Our main findings may be summarized as follows. A monetary aggregate (M2 + CDs) is a relatively useful indicator of monetary policy in the first sample period. Money is a good predictor of output according to one measure used, and responses to money shocks also conform broadly to the implications of the monetary transmission model. In particular, we find some evidence of a "liquidity effect." In this sample, an interest rate indicator has about the same predictive power as money, but responses to interest rate shocks do not entirely conform to the monetary transmission model.

In contrast to the first sample, no entirely successful indicator of monetary policy is identified in the second sample. Although money continues to be a good predictor of output in this sample (much better than interest rates), the responses to innovations in either variable cannot be interpreted as reflecting innovations in monetary policy.

The rest of the paper is organized as follows. Section I describes how financial markets and the approach to monetary policy have changed over time in Japan. Section II describes the macroeconomic models to be estimated, discusses the approach to identification, motivates the selection of variables included in the two alternative models, and summarizes the estimation procedure. Section III reports the results while Section IV provides some conclusions.

I. JAPANESE MONETARY POLICY: INSTRUMENTS AND TARGETS

The monetary transmission model implies a certain relationship among variables that can be influenced by policy—monetary aggregates and interest rates—and the ultimate objectives of policy, such as real economic activity. One issue confronting policymakers is whether to target a monetary aggregate or an interest rate.[4] This policy choice determines whether, in empirical analysis, a monetary aggregate or an interest rate will be a suitable measure of changes in monetary policy. An interest rate (e.g., the

3. The authors base this conclusion on exclusion restrictions or "Granger causality." Ito (1982) finds that the narrower monetary aggregate M1 is not a good predictor of Japanese output in a VAR model, according to variance decompositions. Other studies focus on the ability of money to predict nominal GNP. See the survey by Okina (1985).

4. For a survey of this issue see Friedman (1990).

interbank rate) may be considered a useful indicator of monetary policy if policymakers supply reserves perfectly elastically to target a given interest rate. In this case, shocks to money demand will not affect the targeted rate. A monetary aggregate will be the appropriate indicator of monetary policy if monetary authorities target the aggregate and do not accommodate shocks to demand.[5] Thus the use of either an interest rate or a monetary aggregate as an indicator of monetary policy involves fairly stringent assumptions about the behavior of monetary authorities. In practice, the targets and instruments used by monetary authorities, and the commitment to any given target, vary over time. Financial market development may also affect the ability to control monetary aggregates with precision.

These various considerations make empirical analysis difficult. However, such difficulties may be mitigated by examining the institutional setting and the operating procedure employed by the BOJ, as well as the financial market environment. Such an examination may facilitate the choice of an indicator of monetary policy and the interpretation of any empirical results.[6] In this section we perform such an institutional review, focusing on the following questions. First, has monetary policy in Japan primarily targeted a monetary aggregate or interest rate(s)? Second, given a choice of a particular target (or set of targets), what operational procedure has been used to implement it? Third, how has financial liberalization affected monetary control and the choice of operational procedure and target? To begin, we provide some background on the postwar Japanese financial system.

Japan's Financial System

Throughout most of the postwar period, the task of mobilizing funds from net savers to investors in Japan has fallen primarily on the banking sector. Up to the 1980s, the government intervened actively in this process of intermediation, initially in an effort to promote investment and growth, and later to meet the financing needs of the government. Deposit rates were strictly controlled, while the bank lending rate was anchored to the official discount rate, ensuring a relatively tight link between government interest rate policy and the cost of funds faced by nonbank borrowers. Selective and aggregate credit targeting ensured direct government input in the allocation and growth in credit, as did the heavy reliance of banks on borrowing from the BOJ's discount window. Controls over the nonbank financial sector ensured that market forces would not erode the effectiveness of banking sector controls. For example, the government controlled which firms could issue bonds as well as the corporate bond rate. Finally, exchange and capital controls prevented financial market participants from circumventing regulation via overseas transactions.

Japan's regulated financial system gradually gave way to market forces beginning in the mid-1970s. The main factor appears to have been the slowdown in economic growth in the early 1970s, which sharply reduced government revenues and prompted large increases in government borrowing. Initially, government bonds were allocated to banks at below-market interest rates, but as the volume of borrowing increased, there was strong pressure for the development of an active secondary market in government bonds at a market-determined rate. By arbitrage, this stimulated the development of short-term money markets such as the *gensaki* (repurchase) and CD markets. However, a short-term government debt market did not develop until very recently. The liberalization of financial markets extended to international capital transactions, restrictions on which were progressively dismantled in the course of the 1980s.[7]

Monetary Control Prior to Deregulation

In an environment in which banks dominated as financial intermediaries and the heavily indebted private business sector had virtually no alternative to bank loans for external financing, the BOJ's traditional approach to monetary control consisted of controlling the amount of bank lending to the nonfinancial corporate sector. We can think of this as similar to monetary targeting because, with corporate loans dominating the asset side of banks' balance sheets, bank credit and broad monetary aggregates tended to move very closely for much of the postwar period. While it is clear from accounts of BOJ practices that the BOJ attached a great deal of importance to achieving its credit targets, these credit targets have not been disclosed, so it is unclear whether they were truly exogenous, or whether the BOJ from time to time accommodated shocks to credit demand. Also, the weight the BOJ attached to curbing inflation

5. There may be ambiguities in interpreting the stance of monetary policy when using an interest rate target. Since shocks to demand are fully accommodated, an unchanged interest rate may be consistent with stimulus or contraction in output. Similar difficulties in interpretation may arise when focusing on a money aggregate if money demand is unstable. Such instability became a concern in Japan in the second half of the 1980s, when money growth accelerated with less-than-proportionate increases in nominal income.

6. For example, Strongin (1992) motivates a recursive identification procedure from knowledge of the Federal Reserve's operational procedures. However, his reasoning is not applicable to Japan.

7. For overviews of the postwar Japanese financial system and the process of deregulation, see Feldman (1986) and Hamada and Horiuchi (1987).

prior to the mid-1970s is uncertain, whereas it is apparent that a high weight was attached to curbing inflation since then.

To achieve its credit objectives, the BOJ relied largely on two instruments. First, it sought to influence interest rates in the interbank market. Second, it provided direct guidelines for commercial bank lending.[8]

Interbank Interest Rates. On a day-to-day basis, the BOJ sought to influence the supply of credit and money by targeting the call money rate in the interbank market.[9] To a large extent, the transmission mechanism relied upon interest rate rigidities in the system and the heavy dependence of the corporate sector on bank lending. Loan as well as deposit rates were subject to administrative controls, so banks could not easily pass on to corporate borrowers changes in the interbank rates. In this setting, changes in the call money rate had a direct and immediate impact on bank profitability, and consequently on the growth of money and credit. For example, a rise in the call rate resulting from BOJ tightening would reduce the marginal profitability of lending. In response, banks would ration credit, forcing corporations to curtail investment, and the process would ultimately result in a reduction in the broad money supply.[10]

Accounts of BOJ's operating procedures suggest that reserves were supplied elastically at the call market rate consistent with the targeted level of credit. Monetary authorities paid particular attention to the "reserve progress ratio," which measures reserves accumulated by banks relative to those required within a maintenance period.[11] Notably, call transactions in Japan involved money market brokers (*Tanshi kaisha*). These brokers maintain close informational contact with the BOJ and, in close consultation with the BOJ, set the rate at the opening of the markets each day. If the initially quoted rate failed to equate demand and supply, the BOJ typically would adjust the supply of reserves to achieve equilibrium at its target interest rate.[12]

In the absence of a short-term market for government debt, discount window lending by the BOJ was the main instrument for short-run adjustments of bank reserves. A rationing scheme governed this method of monetary control. The BOJ provided loans to financial institutions (mainly city banks) at the official discount rate (ODR), typically at a rate below the interest rates in the interbank market. BOJ lending thus amounted to a subsidy and Japanese banks naturally preferred to rely on the central bank for liquidity.[13] Consequently, in contrast to the U.S., where the ratio of borrowed reserves to required reserves seldom exceeds 5 percent, the level of discount window borrowing by Japanese banks often has exceeded the level of required reserves.

Direct Control of Bank Credit. Another instrument of monetary control by the BOJ was the direct quantitative control of commercial bank lending through so-called "window guidance." To tighten the supply of money and credit, the BOJ would impose individual ceilings on new lending by commercial banks, in particular, the city banks. In formulating these ceilings, the authorities used information garnered during day-to-day contacts through deposit and lending transactions with individual financial institutions, such as their future loan plans and prospective fund positions. In addition, the BOJ received from city banks reports on a longer-term basis (monthly until 1963 and quarterly thereafter) which included forecasts of future fund-raising activity and the outlook for deposits and loans.

The BOJ had a number of ways to dissuade banks from lending in excess of their prescribed ceiling, such as curbing its discount window lending, thus compelling a bank to borrow in the more expensive call money market or to sell commercial bills. In practice, banks complied with BOJ guidelines with little need of persuasion because of their heavy reliance on BOJ discount window loans for their funds. Thus, according to Suzuki (1980), in no case did a bank exceed the limits imposed up to the late 1970s.

Monetary Control under Financial Liberalization

The mid-1970s initiated a process of financial deregulation and innovation that continues to date. From the vantage point of conducting monetary policy, three changes have been particularly significant. First, the importance of bank

8. The BOJ occasionally also resorted to changes in required reserves. These changes were relatively infrequent, and the use of this instrument was discontinued in 1982.

9. The call market rate is a short-term market comparable to the Federal funds market in the U.S. It is still the BOJ's primary operating target. There is also a bill discount market where commercial bills are discounted.

10. For an authoritative discussion of the transmission channels of monetary policy in Japan, see Suzuki (1980), parts II, III, and IV.

11. The reserve maintenance period in Japan is one month that straddles two calendar months. It runs from the 16th day of a month through the 15th day of the following month.

12. Under such a system, interbank rates could not fluctuate on a daily basis. See Dotsey (1986) and Fukui (1986) for details. Similar operating arrangements are in place today except that interbank rates fluctuate more freely than in the past. See footnote 18.

13. The BOJ decided on the level of bank borrowing (up to a predetermined quarterly ceiling), the term of borrowing, and the interest rate associated with borrowing. Officials at the BOJ could call up each city bank as frequently as daily to indicate how much they could borrow.

loans has sharply declined as a result of the slowdown in corporate investment and the move toward securitization. This, coupled with the large flotation of government bonds, has weakened the link between corporate lending and the monetary aggregate. Second, banks have been able to raise funds from a wider array of financial instruments and markets, such as the CD and euroyen markets, thus reducing their reliance on BOJ credit and eroding BOJ leverage in using credit rationing under window guidance. Third, assets with market-determined prices have come to predominate the portfolios of all sectors of the economy. The disintermediation between administered and market-priced assets has weakened BOJ's traditional transmission channel of altering the spread between interbank rates, on the one hand, and the administered loan and deposit rates, on the other.

These developments have led to a gradual shift from the late 1970s through the 1980s in the objectives of monetary policy. The BOJ began to pay more direct attention to the behavior of monetary—as opposed to credit—aggregates, and in 1978 began announcing "forecasts" of the growth in M2 + CDs. However, it is not clear that the BOJ has fully embraced monetary targeting, as might be inferred from the writings of some influential observers. (Friedman 1985, Meltzer 1986.) First, as BOJ officials emphasize repeatedly, these announced figures are projections rather than targets.[14] There is evidence suggesting that the BOJ has not tried systematically to offset differences between actual and targeted money (Ito 1989, Judd and Hutchison 1992). Second, broad money has not been the sole target, but has served as one of the primary indicators among a group of financial variables (Hamada and Hayashi 1985, Hutchison 1986, and Kasman and Rodrigues 1991). In fact, the BOJ appears to have gradually reduced its emphasis on broad money in recent years while focusing a great deal of attention on market interest rates (e.g. the call rate, the *gensaki* or repurchase rate, and the CD rate).[15]

Concomitant with these changes in the policy targets or indicators, the BOJ's operational procedures have evolved as well. The use of discount window guidance, in the form of the central bank instructing individual banks in their lending plans, was curtailed, although a more limited form of window guidance, through which the BOJ communicated its aggregate lending plans and overall policy stance to individual banks, continued into 1991.

In the wake of financial liberalization, the BOJ also extended its intervention outside the interbank market. The BOJ began open market operations in CDs in 1986, *gensaki* in 1987, and commercial paper in 1989, when active operations in short-term government securities were also initiated.[16] Nevertheless, the call money rate (along with the interbank commercial bill rate) is still the most important interest rate target of the BOJ, and BOJ discount window lending is still the primary mechanism for regulating the quantity of bank reserves.[17] Indeed, the effectiveness of the call market appears to have been enhanced by the greater flexibility in interbank interest rates resulting from deregulation in the late 1970s.[18]

Monetary Control: Summary and Implications

Our discussion sheds light on two important elements of the BOJ's approach to monetary policy in the postwar period. First, with respect to targeting, there is some uncertainty about the precise features of BOJ credit or money targeting. During the earlier periods, credit targets were reportedly consistently met. However, these targets were not announced, so it is unclear whether they were exogenous or adjusted to accommodate shocks to money demand. There also has been disagreement on whether the Bank of Japan actually adopted monetary targeting after 1978. However, BOJ statements suggest that there was no strict targeting as such, and that the behavior of monetary

14. For example, Suzuki states (1986, pp.192-193) that the BOJ focuses on control of the broad money supply but does not set a target. He indicates further that the BOJ "does not follow an operating procedure rule of constant money supply growth." Also, as noted by Judd and Hutchison (1992), these "annual" forecasts which were announced on a quarterly basis actually extended only one quarter ahead; that is, the forecasted annual growth rates are averages of three quarters of realized, and one quarter of projected, money growth. As such, these projections contained relatively little new information on monetary policy stance as compared to, say, the Federal Reserve's targets.

15. The increased attention paid to market interest rates is officially acknowledged by the BOJ staff itself. Nakao and Horii (1991) note, for instance, that the BOJ "has increased the number of reservations it applies to its interpretation of money supply, bank credit and other volume indicators of finance. . . [while] it has enhanced attention given to market interest rate developments."

16. Because of the relatively underdeveloped market for short-term government securities, open market operations in Japan necessarily have relied upon private short-term instruments.

17. See for example, Ohkubo (1983), Suzuki (1986), and Suzuki, et al. (1988).

18. Notable changes in the interbank market include: allowance for more frequent quotations on the call rate and the resale of bills allowed after one month from purchase (June 1978); the introduction of seven-day call money with a freely determined interest rate (October 1978); and the introduction of one-month bills at unregulated rates (November 1978). The process of liberalizing the interbank market was largely concluded in 1979 with the abolition of quotation systems in the call market and the introduction of shorter-term (2-6 days) call money (April) and the liberalization of rates on 2-month bills (October). From late 1979, therefore, rates in both the call and bill market have fluctuated daily (Dotsey 1986).

aggregates was monitored along with other indicators, such as interest rates. BOJ statements also indicate that in recent years the weight assigned to interest rates has increased.

Second, in the credit-dominated regime prior to the onset of financial deregulation and innovation, the BOJ depended more heavily on nonmarket mechanisms for monetary control, such as window guidance, to control money and credit. There were also few substitutes for bank deposits, so portfolio shifts were less likely to affect the behavior of monetary aggregates. It seems plausible to argue that the BOJ's ability to control monetary aggregates precisely was greater during this earlier period than it was later, when the BOJ deemphasized nonmarket mechanisms for control and when the development of financial markets broadened the spectrum of assets available to savers.

Given these characteristics, it seems reasonable to expect that monetary aggregates are unlikely to serve as a good indicator of monetary policy since the late 1970s or early 1980s, when financial innovation began in Japan. Monetary aggregates will serve as a good indicator in the earlier period if credit targets did not accommodate demand shocks which, as stated previously, is not entirely clear. The reason is that during this earlier period financial markets were relatively less developed and the BOJ relied more heavily on direct, nonmarket instruments that are likely to have significantly enhanced the precision of its control. As for interest rates, our institutional review provides no clearcut basis for deciding whether they might serve as useful policy indicators. However, the reader may note that the BOJ appears to have consistently used an interest rate as an operating target, and appears to have paid closer attention to the implications of interest rates for aggregate economic activity as the 1980s progressed. The empirical analysis may clarify some of these uncertainties.

II. THE MODEL

Structural Model and Identification

To motivate the approach followed in this paper, consider an economy described by a vector of nonpolicy variables, Z_t, that may be represented by indicators of economic activity like output and inflation, and a vector of policy variables, I_t, that can be influenced by monetary authorities, such as a monetary aggregate and an interest rate. The interaction by the variables is summarized by the following two equations[19]

$$(1) \quad Z_t = B_0 Z_t + B_1 Z_{t-1} + C_0 I_t + C_1 I_{t-1} + u_t$$

$$(2) \quad I_t = D_0 Z_t + D_1 Z_{t-1} + G I_{t-1} + v_t$$

where u, v are orthogonal disturbances.

One way of identifying this model is to assume that contemporaneous I does not enter equation (1) ($C_0 = 0$), so policy actions affect real variables only with a lag. However, policymakers respond to contemporaneous innovations in macroeconomic activity.

$$(3) \quad Z_t = (I - B_0)^{-1} [B_1 Z_{t-1} + C_1 I_{t-1} + u_t]$$

$$(4) \quad I_t = (D_1 + D_0(I - B_0)^{-1} B_1) Z_{t-1} + (G + D_0(I - B_0)^{-1} C_1) I_{t-1} + v_t + D_0(I - B_0)^{-1} u_t$$

In equation (4) I_t is contemporaneously affected by the policy innovation v_t and also by contemporaneous macroeconomic shocks u_t. Identification as proposed above can be obtained by estimating a VAR comprising Z, I. The orthogonalized innovations that satisfy the recursive structure assumed in equations (3) and (4) can then be identified by applying the Choleski decomposition to the variance-covariance matrix of the residuals, putting I last in the ordering.

The model described above can be used to assess the predictive ability of alternative possible measures of monetary policy by: (i) testing for the significance of exclusion restrictions on monetary policy variables in the industrial production equation, (ii) estimating the respective contributions of orthogonalized innovations in money or interest rates to the variance of the forecast error of output at various horizons. Similar procedures for assessing predictive ability are used by Sims (1980, 1992) and by Bernanke and Blinder (1992).

To ascertain whether responses to monetary variables conform to theoretical expectations, the VAR model can be inverted to obtain the impulse responses (the coefficients of the moving average representation of the model) to orthogonalized innovations in money and interest rates. A comparison of these responses can then be used to assess the extent to which the responses to innovations in these variables conform to the monetary transmission model described earlier.

As is well known, the Choleski identification procedure proposed here has been criticized on a number of grounds. One potential difficulty is that the results can be sensitive to the ordering of the variables.[20] Another difficulty, reflected in the sometimes counterintuitive responses to

19. See Bernanke and Blinder (1992) for a similar discussion.

20. This criticism does not apply to the model used in this paper because the contemporaneous correlations of the residuals of the estimated VAR model are low.

shocks cited earlier in the introduction, is that it is not entirely clear how innovations identified using this procedure are to be interpreted. For example, orthogonalized innovations in money may reflect shocks to money supply or money demand.

At least two responses may be offered to these criticisms. First, the application of these identification methods to Japanese data can actually shed further light on the plausibility of the Choleski identification procedure, which is still widely used in empirical VAR models of the U.S. (The users include authors who have also used alternative identification procedures explicitly based on economic theory, such as Bernanke and Sims). If the responses to shocks broadly conform to theoretical expectations, it can be argued that the Choleski procedure is a reasonable approximation to a model that is identified on the basis of economic theory.

Second, efforts to identify VAR models using economic theory have also been criticized on various grounds. As pointed out by Sims (1986), any empirical study raises debatable questions about identification that will leave readers more or less uncomfortable about applying the conclusions. Under these circumstances, researchers may be well advised to experiment with different approaches to identification. The present paper can then be seen as one step in allowing the data "to speak" about Japanese macroeconomic behavior.[21] Future studies that attempt to utilize alternative identification procedures are not ruled out.

The Model

A four-variable monthly VAR model for Japan was estimated, comprising industrial production (IP) to represent output, the consumer price index (CPI) to represent price, a broad monetary aggregate (M2+CDs) to represent money, and the interbank call money rate (CMR) to represent interest rates. The variables were entered in this order in identifying the orthogonalized innovations.[22] The data span the period 1961.1–1992.8. Data and sources are described in the Appendix.

As discussed earlier, financial liberalization and changes in the Bank of Japan's approach to monetary policy are likely to have affected the relationship between money and interest rates and economic activity. This suggests that it would be desirable to estimate the model over two subsamples. The first subsample would correspond to the period when financial markets were undeveloped, commercial banks were heavily dependent on the BOJ for funding, and the BOJ emphasized credit targets and sought to influence bank behavior directly through window guidance. The second would correspond to the period when financial markets were more developed, commercial banks had more access to sources of financing outside the BOJ (including external financing), and the BOJ paid more attention to money and interest rates (rather than credit) and began to rely more heavily on market-based mechanisms for monetary control.

Given the gradual pace of financial innovation in Japan, there is no obvious single candidate for a break date. Likely candidates for a break date are somewhere between 1975, when large quantities of government bonds were first issued, and 1981, when Japan's foreign exchange controls were first liberalized. The date 1981.1, which is the first month after foreign exchange controls were liberalized in Japan, is selected as a reasonable candidate. At that time, the liberalization of controls loosened the dependence of Japanese commercial banks on the Bank of Japan by allowing them to draw on foreign sources of funding. Also, the impact of gradual financial liberalization on macroeconomic relationships is more likely to have been manifest by then. Thus, the first sample period spans 1961.1–1980.12, and the second, 1981.1–1992.8.

To account for non-stationarity in the data, the model was estimated in first differences of the logs of the variables, with the exception of the interest rate, where the first difference of the series was used.[23] As the frequency of the data was monthly, lag lengths were set at 12 for both subsamples. No other criterion was used in setting the lag length.

III. RESULTS

Predictive Ability

To assess the predictive ability of alternative monetary indicators, Table 1 reports the results of tests for exclusion restrictions on the right-hand-side variables of the output

21. Structural VAR models of the Japanese economy have been estimated by Hutchison and Walsh (1992), Hutchison (forthcoming), and Moreno (1992). However, none of these models are explicitly designed to analyze monetary policy.

22. The ordering places M2+CDs prior to CMR, which assumes that the former is contemporaneously unaffected by innovations to the latter. However, the correlation between residuals in the M2+CDs and the call money rate equations is small, about 8 percent in the first subsample and 18 percent in the second. Thus, the results are not likely to be very sensitive to the ordering assumed.

23. As is by now well-known, however, there is a great deal of uncertainty surrounding the stochastic properties of macroeconomic data (Cochrane 1991, Rudebusch 1992).

(industrial production) equation and the results of variance decompositions of the forecast error of output.

In the first subsample, tests of exclusion restrictions indicate that money is a good predictor of output; in fact, it is better than the interest rate. The evidence offered by variance decompositions is mixed. Money and the interest rate make similar (and relatively small) contributions to the variance of the forecast error after two years, after which the contribution of money falls off, while the contribution of the call money rate remains about the same. It is worth noting the Japanese economy experienced relatively large supply shocks during this period (notably, large declines in productivity and growth), and also fiscal policy shocks, and these may have tended to reduce the observed contribution of the monetary indicators (money or interest rates) to the variance of the forecast error of output.

For this sample, money and the interest rate are both generally good predictors of output, so the criterion of predictive ability does not allow us to choose unambiguously between the two. An analysis of responses to innovations in each of these variables is needed to shed further light on which variable may be a better indicator of monetary policy in Japan in this sample period. This is in contrast to Sims's (1980) well-known result for the U.S. case, which found that interest rates rob the monetary aggregate of predictive power. According to the criterion of predictive ability, in the U.S. the interest rate is favored over money as an indicator of monetary policy innovations.

In the second subsample, tests of exclusion restrictions as well as the variance decomposition results indicate that the monetary aggregate is a much better predictor of output than is the call money rate. At a two-year horizon, money accounts for 58 percent of the variance of the forecast error of output in the second sub-sample, compared to 1 percent for the call money rate. In fact, the predictive power of money is much larger in the second subsample (58 percent) than in the first subsample (13 percent).

Our findings on predictive ability are consistent with some previous studies of the Japanese economy that use similar techniques and also replicate some ambiguities observed in this literature. In particular, the finding that money is a good predictor of real GNP according to exclusion restrictions in both subsamples is consistent with Suzuki, et al. (1988) which findings are based on a five-variable VAR over the period 1968.Q1–1987.Q4.[24] It is also interesting that our finding that money is not a good predictor of output according to variance decompositions for the first subsample is similar to Ito's (1982) findings using M1 over a similar period.

TABLE 1

INDUSTRIAL PRODUCTION

	TESTS OF EXCLUSION RESTRICTIONS			
	IP	CPI	M2+CDs	CMR
1960.1-1980.12	8.7×10^{-6} **	.04 *	8.4×10^{-4} **	2.7×10^{-3} **
1981.1-1992.8	.02 *	.14	.04 *	.56

	VARIANCE DECOMPOSITION (PERCENT)				
	Months	IP	CPI	M2+CDs	CMR
1960.1-1980.12	12	79	8	11	1
	24	27	44	13	15
	36	16	60	8	16
1981.1-1992.8	12	54	7	39	1
	24	26	15	58	1
	36	15	21	64	0

NOTES:
** Significant at 1%
* Significant at 5%

To sum up, the preceding findings provide mixed evidence that both money and interest rates are good predictors of output in the first sample. Money is a much better predictor of output in the second sample. These findings support the view that money may be a useful indicator of monetary policy, perhaps better than the interest rate. However, such a conclusion is valid only if innovations to money satisfy the predictions of the monetary transmission model, while innovations in interest rates do not. We turn to this question now.

Do Responses Conform to the Monetary Model?

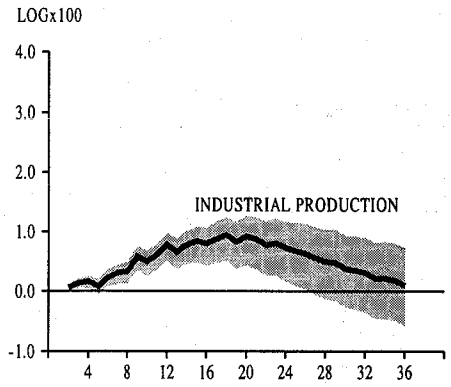
To assess whether innovations to money or interest rates conform to the predictions of the monetary transmission model, Figure 1 reports the point estimates of the responses of the variables to innovations in monetary aggregates in the first and second samples, while Figure 2 illustrates the corresponding responses to interest rate innovations. The shaded area illustrates one standard error band around

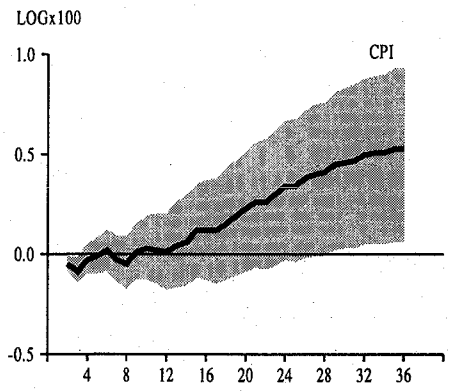
24. The Suzuki, et al. (1988) model comprises base money, the weighted average of the call money rate and the bill rate, M2 + CDs, real output, and the GNP deflator. Other studies have focused largely on the ability of money to predict nominal output. See also the survey by Okina (1985).

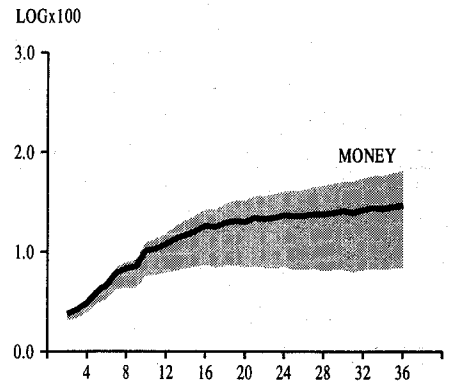
FIGURE 1

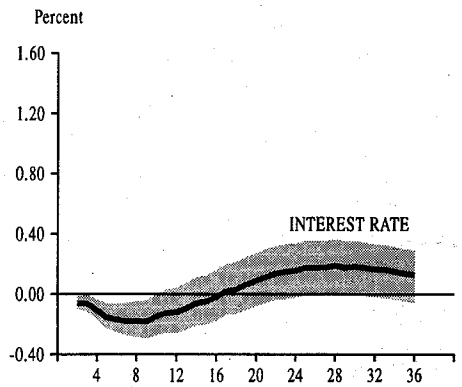
Responses to Innovations in Money

1960.1–1980.1

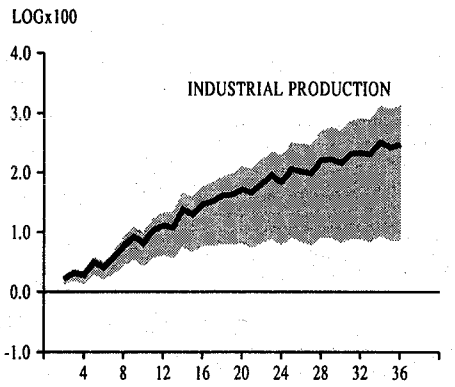


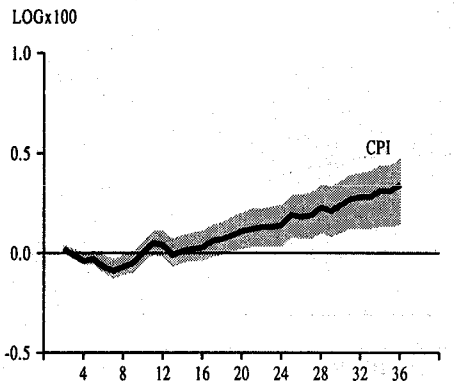


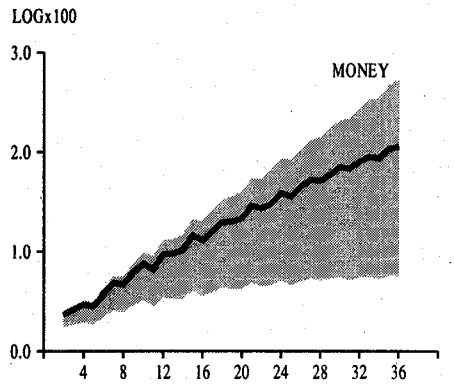




1981.1–1992.8







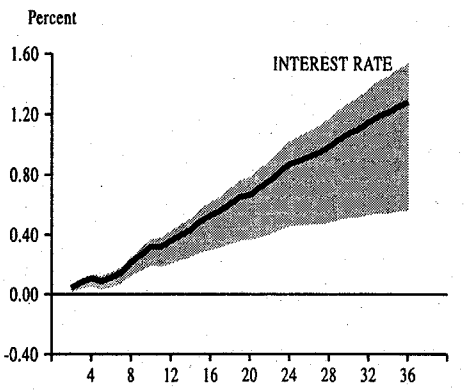
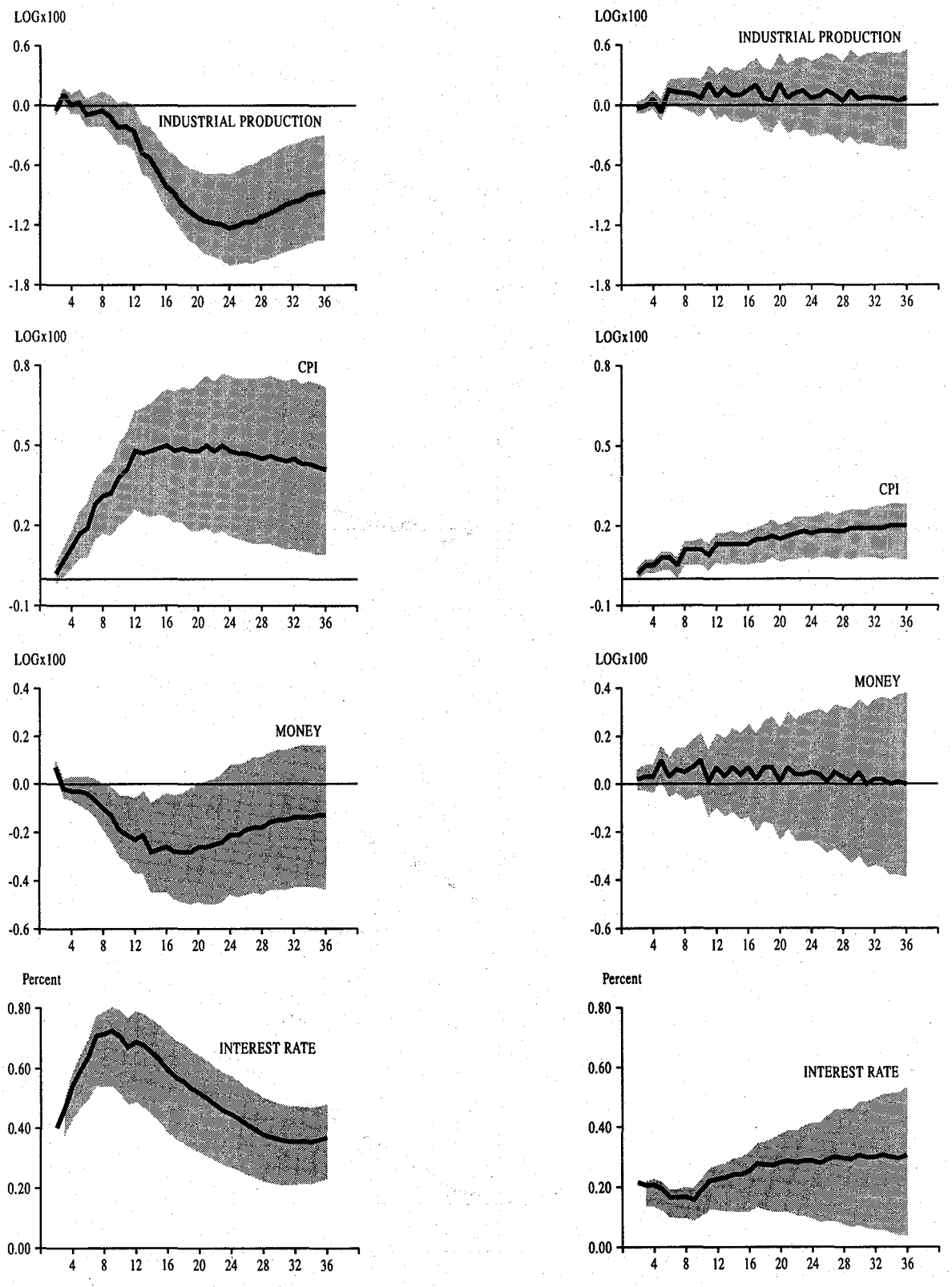


FIGURE 2

RESPONSES TO INNOVATIONS IN INTEREST RATES

1960.1–1980.1 1981.1–1992.8



the point estimate. The standard errors are obtained using a bootstrapping procedure.[25]

Focusing on the point estimates, in the first subsample an innovation to money is associated with a fall in the interest rate below its initial level that persists for about a year and a half, followed by a persistent rise that is subsequently reversed. Thus, there appears to be a "liquidity effect" in this model. Other responses to innovations in money are broadly consistent with the monetary transmission model. In response to a monetary aggregate shock, output rises temporarily, while prices rise after about one year.

In response to a positive interest rate innovation, money falls, and output falls. However, there is an extended increase in the price level that is difficult to interpret. A similar "price puzzle" was found by Sims (1992, 1986) for Japan and the U.S. While the responses to innovations in interest rates are difficult to interpret, one possibility is that they reflect aggregate supply shocks. This would account for a set of events where interest rates rise, output falls, and the price level rises. An alternative explanation, offered by Sims, is that interest rate innovations reflect an effort by monetary authorities to offset anticipated increases in prices. However, the inflationary pressure is not entirely offset so an increase in price is observed following the increase in the interest rate.

Figure 1 indicates that in contrast to the first subsample, in the second sub-sample an innovation in money is associated with an increase in the interest rate. Thus, there appears to be no liquidity effect. As in the first subsample, output, prices and money increase; however, the responses of output and money are much larger and more persistent than in the first subsample. The direction of the responses suggests that money innovations are demand shocks. However, the persistence of the responses suggests the presence of permanent supply shocks. Thus, innovations to money are not easily interpreted in this sample. Figure 2 reveals that all the variables in the model now rise in response to an innovation in interest rates (in the case of output, after an initial decline). These results suggest that an increase in interest rates reflects increases in the demand for money rather than a tightening in policy.

To sum up, the responses to innovations in money in the first sample fit the predictions of the monetary transmission model, but do not do so in the second sample. Responses to innovations in interest rates do not consistently fit the predictions of the monetary transmission model in either period. Taken together with the results on predictive ability cited earlier, money appears to be a relatively useful indicator of monetary policy shocks in the first sample. In contrast, the methods used in this paper do not successfully identify a monetary policy indicator in the second sample. The results for the first sample should be interpreted with caution, because estimates are in some cases imprecise. Nevertheless, they are quite interesting, as they suggest that financial market development may have contributed to reducing the usefulness of money as an indicator of monetary policy in Japan.

The preceding results may also be compared to those reported in Sims (1992) which studied several industrial economies, including Japan. Sims finds that the response of output to a monetary innovation is negative and is not associated with a liquidity effect. To isolate the reasons for the differences, we reestimated the model using M1 over two subsamples, and found that Sims's results differ from ours largely because he uses M1 rather than M2 + CDs as a monetary aggregate.

IV. CONCLUSIONS

This paper provides suggestive evidence that a broad monetary aggregate is a better indicator of monetary policy than an interest rate during the period when Japan's financial markets were less developed, the BOJ focused on a credit target and relied more heavily on nonmarket instruments for monetary control to achieve its policy target. During this period, there is mixed evidence that both a monetary aggregate and an interest rate are good predictors of output. However, analysis of the responses to shocks suggests that the monetary aggregate is the better indicator of monetary policy. Responses to money shocks broadly conform to the implications of the monetary transmission model, whereas the responses to interest rates do not. In particular, point estimates indicate the existence of a liquidity effect in response to innovations in a monetary aggregate. Responses to interest rate innovations suggest that such innovations may reflect aggregate supply shocks or policy responses to anticipated inflation.

In the second period, when Japan's financial markets became more developed, and the BOJ appeared to adopt a more eclectic approach to monetary policy, money is

25. To construct the standard error band, we bootstrapped the residuals of the VAR. The residuals were used to construct artificial series for the variables in the models. The VARs were then rerun using the artificial series and the impulse responses were recomputed. The simulations were repeated 1200 times. The one standard error band was computed by taking the square root of the mean squared deviation of the artificial impulse responses (above and below) from the point estimate at each step. By construction, the impulse responses obtained using the original data are inside the band. They are also asymmetric. This resembles the procedure used by Blanchard and Quah (1989). It may be noted that in a few cases, the actual responses to shocks fell partly outside the space spanned by the artificial impulse responses. In these cases, the standard error bands are not shaded over the applicable horizons. This difficulty should be borne in mind in interpreting the results.

unambiguously a good predictor of output, whereas the interest rate is not. However this does not imply that money is a good indicator of policy, as the responses to innovations do not conform to the monetary transmission model. In particular, there is no evidence of a liquidity effect, suggesting that money innovations are better interpreted as reflecting shocks to demand rather than policy changes. Interest rate innovations also appear to reflect shocks to demand.

As is often the case in this type of analysis, the estimates are in some cases imprecise and should be interpreted with caution. Nevertheless, they are quite interesting, as they suggest that financial market development may have contributed to reducing the usefulness of money as an indicator of monetary policy. As discussed in our institutional review, this may have occurred because financial market development encouraged the Bank of Japan to pay greater attention to interest rates and also loosened the control of monetary authorities over the monetary aggregate. Similar forces may explain why researchers have had difficulty in identifying an indicator of monetary policy in the U.S., where financial markets have been much more developed than Japanese financial markets in the postwar period.

APPENDIX

Data Description and Sources

Consumer Price Index, Seasonally Adjusted (CPI): Index of consumer prices covering the whole country excluding single-person households and those engaged mainly in agriculture, forestry, and fishing. Base year is 1985. Seasonally adjusted by Federal Reserve Bank of San Francisco staff using X-11 filter. Source: International Monetary Fund, *International Financial Statistics* (IFS).

Industrial Production, Seasonally Adjusted (IP): Index of monthly production by 9 mining and 523 manufacturing industries, weighted by 1985 value-added data. Base year is 1985. Seasonally adjusted by Federal Reserve Bank of San Francisco staff using X-11 filter. Source: IFS.

Call Money Rate (CMR). Rate in interbank call money market. Source: Bank of Japan.

M2 + CDs, Seasonally Adjusted: M1 plus quasi-money (time, savings, and foreign currency deposits of resident sectors other than central government) plus certificates of deposit in trillions of yen. End of month. Seasonally adjusted by Federal Reserve Bank of San Francisco Staff by applying X-11 filter. Source: IFS.

REFERENCES

Bernanke, Ben, and Alan Blinder. 1992. "The Federal Funds Rate and the Channels of Monetary Transmission." *American Economic Review* 82, pp. 901-921.

Blanchard, Olivier Jean, and Danny Quah. 1989. "The Dynamic Effects of Aggregate Demand and Supply Disturbances." *American Economic Review* 79, pp. 655-673.

Bryant, R. 1991. "Model Representations of Japanese Monetary Policy." *Bank of Japan Monetary and Economic Studies* 9, pp. 11-61.

Christiano, Lawrence J., and Martin Eichenbaum. 1992. "Liquidity Effects, Monetary Policy and the Business Cycle." NBER Working Paper No. 4129.

Cochrane, John. 1991. "A Critique of the Application of Unit Root Tests." *Journal of Economic Dynamics and Control* 15, pp. 275-284.

Dotsey, Michael. 1986. "Japanese Monetary Policy, a Comparative Analysis." *Bank of Japan Monetary and Economic Studies* 4, pp. 105-127.

Eichenbaum, Martin. 1992. "Comments on ' Interpreting the Macroeconomic Time Series Facts: The Effects of Monetary Policy by Christopher Sims'." *European Economic Review* 36, pp. 1001-1011.

Feldman, R.A. 1986. *Japanese Financial Markets*. Cambridge, Mass: MIT Press.

Friedman, Benjamin. 1990. "Targets and Instruments of Monetary Policy." In *Handbook of Monetary Economics,* Volume II, Benjamin Friedman and Frank H. Hahn, eds. Amsterdam/New York: North Holland.

Friedman, Milton. 1985. "Monetarism in Rhetoric and in Practice." In *Monetary Policy in Our Times,* A. Ando, H. Eguchi, R. Farmer, and Y. Suzuki, eds., pp. 15-28. Cambridge, Mass: MIT Press.

Fukui, T. 1986. "Recent Developments of the Short-term Money Market in Japan and Changes in Monetary Control Techniques and Procedures by the Bank of Japan." Special Paper No. 130. The Bank of Japan Research and Statistics Department.

Hamada, K., and F. Hayashi. 1985. "Monetary Policy in Postwar Japan." In *Monetary Policy in Our Times,* A. Ando, H. Eguchi, R. Farmer, and Y. Suzuki, eds. Cambridge, Mass: MIT Press.

_____, and A. Horiuchi. 1987. "The Political Economy of the Financial Market." In *The Political Economy of Japan.* Vol. 1, K. Yamamura and Y. Yasuba, eds. Stanford: Stanford University Press.

Hutchison, Michael M. Forthcoming. "Structural Change and Macroeconomic Effects of Oil Shocks: Empirical Evidence from the United States and Japan." *Journal of International Money and Finance.* Issued as Working Paper No. PB92-06. Center for Pacific Basin Monetary and Economic Studies, Economic Research Department, Federal Reserve Bank of San Francisco.

_____. 1986. "Japan's 'Money Focused' Monetary Policy." Federal Reserve Bank of San Francisco *Economic Review* (Summer) pp. 33-46.

_____, and Carl Walsh. 1992. "Empirical Evidence on the Insulation Properties of Fixed and Flexible Exchange Rates: The Japanese Experience." *Journal of International Economics* 32, pp. 241-263.

Ito, T. 1982. "A Comparison of Japanese and U.S. Macroeconomic Behavior by a VAR Model." Discussion Paper No. 82-162. University of Minnesota. As reported in K. Okina, 1985.

_____. 1989. "Is the Bank of Japan a Closet Monetarist? Monetary Targeting in Japan, 1978-88." NBER Working Paper 2874.

Judd, J., and M. Hutchison. 1992. "Central Bank Secrecy and Money Surprises: International Evidence." *Review of Economics and Statistics* 74, pp. 135-145.

Kasman, B., and A. Rodrigues. 1991. "Financial Liberalization and Monetary Control in Japan." Federal Reserve Bank of New York *Quarterly Review* (Autumn).

Leeper, Eric M., and David B. Gordon. 1992. "In Search of the Liquidity Effect." *Journal of Monetary Economics* 29, pp. 341-369.

Meltzer, A. 1986. "Lessons from the Experiences of Japan and the United States under Fixed and Fluctuating Exchange Rates." *Bank of Japan Monetary and Economic Studies* 4(2) pp. 1-46.

Moreno, Ramon. 1992. "Are the Forces Shaping Business Cycles Alike? The Evidence from Japan." Working Paper No. PB92-10. Center for Pacific Basin Monetary and Economic Studies, Federal Reserve Bank of San Francisco.

Nakao, M., and A. Horii. 1991. "The Process of Decision-Making and Implementation of Monetary Policy in Japan." Special Paper No.198. The Bank of Japan Research and Statistics Department.

Ohkubo, T. 1983. "Money, Interest, Income and Prices." *Bank of Japan Monetary and Economic Studies* 1, pp. 111-146.

Okina, K. 1985. "Empirical Studies Using Granger Causality." *Bank of Japan Monetary and Economic Studies* 3, pp. 129-162.

Rudebusch, Glenn D. 1992. "Trends and Random Walks in Macroeconomic Time Series: A Re-examination." *International Economic Review* 33, pp. 661-680.

Sims, Christopher A. 1992. "Interpreting the Macroeconomic Time Series Facts: The Effects of Monetary Policy." *European Economic Review* 36, pp. 975-1000.

_____. 1986. "Are Forecasting Models Usable in Policy Analysis?" Federal Reserve Bank of Minneapolis *Economic Review* (Winter) pp. 2-16.

_____. 1980. "Comparison of Interwar and Postwar Business Cycles: Monetarism Reconsidered." *American Economic Review* 70, pp. 250-257.

Strongin, Stephen. 1992. "The Identification of Monetary Policy Disturbances: Explaining the Liquidity Puzzle." Working Paper Series WP-92-27. Federal Reserve Bank of Chicago.

Suzuki, Y. 1986. *Money, Finance, and Macroeconomic Performance in Japan.* New Haven: Yale University Press.

_____. 1980. *Money and Banking in Contemporary Japan.* New Haven: Yale University Press.

_____, A. Kuroda, and H. Shirakawa. 1988. "Monetary Control Mechanism in Japan." *Bank of Japan Monetary and Economic Studies* 6, pp. 1-27.

Yasuda, T. 1981. "A Theoretical Interpretation of Window Guidance: A Game Theoretic Interpretation." Discussion Paper Series No. 4. Bank of Japan.