Financial Liberalization and Monetary Control in Japan

by Bruce Kasman and Anthony P. Rodrigues

The last fifteen years have witnessed a substantial liberalization of Japan's financial markets. Controls on cross-border capital flows have been gradually dismantled and restrictions affecting competition and price flexibility in domestic financial markets have been relaxed. As a result, the range of free market assets has grown significantly, as has the range of credit sources available to domestic borrowers.

The experience of other industrial countries indicates that changes in financial structure can have important implications for the conduct of monetary policy. A number of countries substantially revised their operating procedures during the past decade as financial market changes altered the relationships between policy tools and objectives.

This article examines the effects of financial reforms on Japanese monetary policy. In the first section of the article we discuss how the Bank of Japan has altered its operating strategy in response to the evolving financial environment. We focus in particular on changes in the intermediate objectives of monetary policy and in the instruments used to implement policy. Our analysis suggests that the complex system of controls prevailing in the mid-1970s supported an operating strategy designed to influence the supply of bank credit. With the relaxation of these controls, monetary policy authorities shifted their strategy away from the control of credit aggregates and, in recent years, have increasingly emphasized interest rates as an agent of policy transmission.

The article's second section offers an empirical assessment of the monetary control mechanism in the current liberalized environment. Specifically, we evaluate the degree to which the Bank of Japan has been able to influence market interest rates and broad money through interbank interest rates, its chief operating target. We find that monetary policy changes have elicited strong and consistent interest rate responses across the term structure in recent years. In particular, long-term bond yields are much more responsive to monetary policy actions than in the past. In contrast, our analysis of the relationship between money and interest rates indicates that as financial reform has reduced policy makers' direct influence over banks, the link between policy and broad money may have weakened.

Our results do not address the extent to which monetary policy actions have been transmitted to real activity or prices. Nonetheless, our findings suggest that the Bank of Japan has successfully adapted its operating strategy to the changing financial environment.

Evolution of monetary control in Japan

In Japan, as in most countries, the ultimate goals of monetary policy are output growth and inflation management. The authorities typically tighten monetary policy to reduce inflationary pressures and ease policy to stimulate activity. Output and prices are controlled only indirectly and with lags, however. Policy actions first affect financial markets and only over time can be expected to influence real activity and prices.

Because financial markets play a central role in transmitting monetary policy, policy makers generally base

their operating strategy on financial variables [1] In particular, a financial variable subject to a high degree of control by authorities usually serves as the target for day-to-day operations Borrowed reserves and the fed funds rate are generally viewed as the current operating targets employed by the Federal Reserve in the United States [2] In Japan, the reserve progress ratio, the ratio of reserves accumulated within a monthly maintenance period to total required reserves, and interbank interest rates have served a similar function since the mid-1970s.

Financial variables are also employed as intermediate targets or indicators. As the term "intermediate " suggests, these variables fit between the instruments and operating targets of policy, on the one hand, and the ultimate policy goals, on the other. To be effective, an intermediate variable should provide information about policy goals and bear some relation to operating targets. In the late 1970s and early 1980s a number of central banks used a monetary aggregate as a key intermediate variable, in many cases setting explicit targets for its annual growth In recent years, reliance on monetary aggregates as explicit intermediate targets has diminished and attention has shifted to a wider set of financial market variables

[1]A more complete description of the role of targets and indicators in the implementation of monetary policy can be found in Richard G Davis, "Intermediate Targets and Indicators for Monetary Policy An Introduction to the Issues," this *Quarterly Review*, Summer 1990

[2]Borrowed reserves are obtained by banks directly from the Federal Reserve discount window The federal funds rate is the rate depository institutions charge one another to borrow reserves

The movement away from monetary targeting has largely stemmed from changes in the financial environment. The remainder of this section considers how deregulation, globalization, and innovation in Japan's financial markets over the past two decades have shaped the Bank of Japan's policy and operating strategy

The monetary control mechanism: mid-1970s

Until the mid-1970s, the Japanese financial system was highly regulated A complex system of controls had evolved, limiting interest rate movements and the activities of market participants.[3] This system ensured that large personal sector surpluses were transferred through banks to large corporations to promote high rates of domestic capital formation [4]

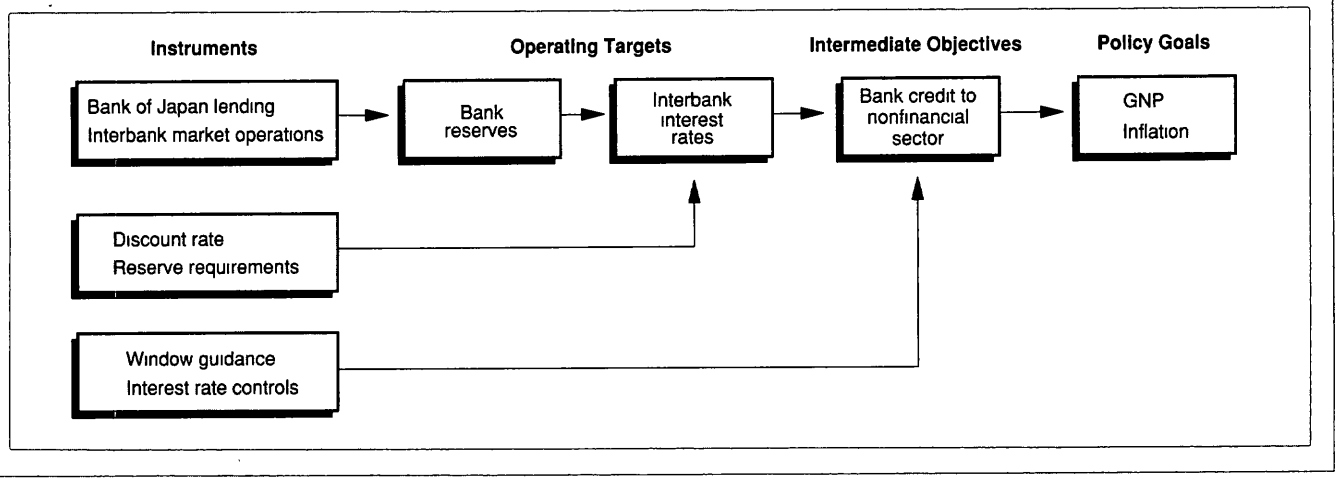
In this highly regulated environment, the Bank of Japan's operating strategy was designed to control bank credit to the nonfinancial private sector The monetary policy control mechanism during the mid-1970s is summarized in Chart 1 Day-to-day policy operations

[3]For a detailed discussion of the structure and evolution of the Japanese financial system, see Robert A Feldman, *Japanese Financial Markets Deficits, Dilemma, and Deregulation* (Cambridge MIT Press, 1986), and Yoshio Suzuki, ed , *The Japanese Financial System* (London IFR Books, 1987)

[4]Generally, households were able to invest their savings only in bank deposits, and banks had few alternatives to lending these funds to corporations Neither the corporate nor the banking sector had significant direct recourse to raising funds in open capital markets, which consequently remained undeveloped Because interest rates were administratively controlled and often held below market-clearing levels, major corporations could borrow cheaply, while smaller firms and individuals faced stringent credit constraints

Chart 1

Japan's Monetary Control Mechanism: Mid-1970s



took the form of interbank market activities or Bank of Japan lending to banks These operations affected the rate at which banks accumulated reserves during a maintenance period as measured by the reserve progress ratio [5] Because lending by the Bank of Japan made up a large component of bank reserves and banks were almost exclusively limited to the interbank market as an alternative source of funds, the response of interbank interest rates to changes in bank reserves was strong and highly predictable.[6]

Changes in interbank interest rates, in turn, influenced the quantity of credit provided by banks. Administrative controls on loan (and deposit) rate movements limited banks' ability to pass on interbank rate changes to their customers [7] Thus, higher interbank rates led banks to ration credit and, given the heavy dependence of the corporate sector on bank lending, prompted cutbacks in expenditures. The Bank of Japan actively used several other supplementary instruments, including quantitative lending limits on individual banks (window guidance), discount rate changes, and adjustments in reserve requirements, to secure a desired level of bank lending, particularly in periods of tightening.

Financial liberalization: 1974-89

Economic growth slowed markedly after 1973 and was accompanied by a sharp decline in the share of output devoted to investment Net corporate borrowing as a share of GNP fell by more than half from its 7 percent average share over 1965-74 (Table 1) At the same time, the demand for borrowing by the public sector more than doubled during the 1970s, and Japan's tendency to run persistent current account surpluses, interrupted only by oil price shocks, became more pronounced

These macroeconomic changes dramatically altered the flow of funds in the Japanese economy, creating pressures that eroded the tight restrictions on financial activity.[8] In particular, the large increase in government borrowing was pivotal in the development of active secondary markets in securities. During the 1960s and early 1970s, initial issues of government bonds were bought by a syndicate of financial institutions at prices fixed by the Bank of Japan. These initial fixed prices, combined with the Bank of Japan's promise to repurchase the bonds, significantly limited the development of secondary securities markets [9] After 1975, however, the large scale of government bond issues threatened to undermine monetary control (because of the Bank of Japan promise to repurchase) and forced banks to raise the share of bonds in their portfolios at a time when attractive alternative investment opportunities were becoming available These developments led to a number of reforms liberalizing bond issue rates, removing restrictions on the sale of bonds in secondary markets, and expanding the bonds' maturity range [10] By

[5]If banks fulfill their requirements along an average path, the reserve progress ratio increases by 3 3 percentage points each day The Bank of Japan adjusts aggregate reserves to determine this ratio and transmit actions to the interbank market

[6]Banks and securities corporations exchange funds in two interbank markets the call market, a short-term market analogous to the U S federal funds market, and the bill discount market, where commercial bills are rediscounted Interest rates in the interbank market are theoretically free from control Nevertheless, because money market brokers have until recently set interbank rates in close consultation with the Bank of Japan, the Bank has had considerable short-term influence on interbank rates

[7]Higher interbank interest rates were passed on to corporate borrowers in the form of higher deposit-to-loan ratios and of increases in loan rates tied to the Bank of Japan's discount rate Although these rate movements allowed policy to affect expenditure decisions through financial price changes, they were less significant than the effects of credit rationing

[8]Good discussions of Japanese financial reform through the mid-1980s can be found in the *OECD Economic Survey—Japan* (Paris OECD, 1984), Suzuki, *The Japanese Financial System*, and Thomas F Cargill, "Japanese Monetary Policy, Flow of Funds, and Domestic Financial Liberalization," Federal Reserve Bank of San Francisco *Economic Review*, Summer 1986, pp 21-32 For analysis of the more recent liberalization process, see K Osugi, "Japan's Experience of Financial Deregulation since 1984 in an International Perspective," *BIS Economic Papers*, no 26, January 1990, Masaaki Nakao and Akinari Horii, "Changes in the Monetary Control Techniques and Procedures by the Bank of Japan," Bank of Japan Research and Statistics Department, Special Paper no 195, 1991, and Kumiharu Shigehara, "Japan's Experience with the Use of Monetary Policy and the Process of Liberalization," *Bank of Japan Monetary and Economic Studies*, vol 9, no 1 (March 1991)

[9]The high commissions promised to the syndicate upon resale of the bonds after the holding period raised the effective interest rate earned by subscribers

[10]For a more detailed discussion of these issues, see Suzuki, *The Japanese Financial System*, or Michael Dotsey, "Japanese Monetary

Table 1

Net Lending by Sector

(As a Percentage of Nominal GNP)

	1965-74 Average	1975-84 Average	1985-90 Average
Corporate business	−7 1	−2 9	−4 3
Personal sector	9 4	10 3	9 0
Public sector	−2 6	−7 1	−1 3
Rest of world	−0 7	−0 8	−2 9
Memo			
Real GNP growth	8.1	4 0	4 8

Sources "Flow of Funds in Japan in 1990," Bank of Japan Research and Statistics Department, Special Paper no 204, July 1991, "Flow of Funds in Japan in 1989," Bank of Japan Research and Statistics Department, Special Paper no 191, August 1990

the early 1980s, turnover in Japan's secondary government bond market had become the second largest in the world.[11]

The increased supply of government bonds also encouraged the development of short-term money markets. In the late 1960s, the gensaki market, involving repurchase transactions largely using government bonds, arose as a vehicle for nonbank short-term financing. Liquidity in this market was significantly boosted by the growth in government bond issuance, and by the mid-1970s, the gensaki market had become a major unregulated short-term money market for nonfinancial corporations.

The growth of the gensaki market made it difficult for the Bank of Japan to maintain deposit rate ceilings. Attracted by rising market interest rates in the late 1970s, corporations were shifting their bank deposits to gensaki assets. Pressure by banks led authorities, in May 1979, to permit banks to issue certificates of deposits (CDs).[12]

The emergence of freer domestic capital markets coincided with the loosening restrictions on international capital transactions. Capital outflows were gradually liberalized to contain upward pressure on the yen after 1973 while capital inflows remained highly restricted throughout the decade. However, after the second oil price shock placed downward pressure on the yen, a more general relaxation of controls was implemented under the Foreign Exchange and Foreign Trade Control Law in December 1980.[13]

The rise in Japan's global surpluses in the first half of the 1980s, particularly its bilateral surplus with the United States, placed increased international pressure on Japan to accelerate financial liberalization. In 1984, a package based on the findings of a special committee set up by the U.S. Treasury and Japanese Ministry of Finance was announced. Most notably, new measures reduced restrictions on Euroyen activities, including Japanese resident borrowing and bond issues by Japanese and foreigners. In addition, limits on forward foreign exchange transactions and swap limit rules on Japanese banks were abolished. Subsequently, limits on the purchase of foreign securities by Japanese nonbank institutional investors were lifted.

The second half of the 1980s saw continued efforts to deregulate domestic markets. The liberalization of interest rates on bank time deposits began in 1985 and is expected to be completed in 1993. Money market certificate deposits were introduced in 1985; restrictions on the minimum denomination, length of maturity, and amounts issued have been steadily relaxed on these accounts as well as on CDs and time deposits.[14]

The changing financial market environment

Financial liberalization and the associated process of financial innovation have had far-reaching effects on Japan's financial system. Many constraints on portfolio and expenditure choices have been removed, altering the tightly controlled flow of funds patterns that supported the monetary control mechanism of the mid-1970s. Three changes have been particularly significant in the evolution of the Bank of Japan's operating strategy: First, the importance of bank loans as a source of funds has greatly declined. Second, the range of instruments used by banks to raise funds has expanded dramatically. Third, assets with market-determined prices now predominate in the portfolios of all sectors of the economy.

We have seen that bank credit was employed as an intermediate target of policy in the mid-1970s largely because of its central role in channeling funds between lenders and borrowers. Before 1974, bank lending accounted for close to three-quarters of intermediated funds in Japanese markets (Table 2). In the second half of the 1970s, however, the importance of bank lending declined sharply as public sector bond issues increased and corporate sector capital spending growth slowed.

Recent years have seen a further decline in the size of domestic loans in Japan's flow of funds. The internationalization of Japan's financial activities has combined with the corporate sector's steady move towards securitization to reduce the share of domestic loans to less than half of all intermediated funds flowing through

Footnote 10 (continued)
Policy, A Comparative Analysis," *Bank of Japan Monetary Economic Studies*, vol 4, no 2 (1986)

[11]According to the *OECD Economic Survey–Japan*, turnover in the Japanese bond market reached 200 trillion yen in 1981, about one-quarter the size of the turnover in U S bond markets and almost three times the turnover in the U K bond market

[12]Secondary market trading in CDs did not begin until May 1982

[13]The lifting of these capital controls resulted in large increases in both inward and outward capital flows In addition, the lifting of controls on nonresident transactions in Japanese money markets led to considerably closer integration of Japanese money markets with those in Europe and the United States As a number of studies have shown, interest rates in Euroyen markets and in the domestic gensaki market became virtually equalized by 1982. For example, see Bruce Kasman and Charles Pigott, "Interest Rate Divergences among the Major Industrial Nations," this *Quarterly Review*, Autumn 1988, pp. 28-44, and Jeffrey Frankel, "International Financial Integration. Relations among Interest Rates, Exchange Rates, and Monetary Indicators," in *International Financial Integration and the Conduct of Monetary Policy*, Federal Reserve Bank of New York, 1990

[14]A number of actions have also been taken to promote deepening of short-term money markets A yen-denominated bankers' acceptance market was launched in June 1985 and a commercial paper market opened in 1987 In addition, a variety of short-term government bond issues have been introduced, and measures have been taken to expand the maturity structure in the interbank market

Japan.[15]

At the same time that domestic credit declined in importance, the Bank of Japan's control over bank lending decisions weakened. The gradual removal of restrictions on bank behavior enabled banks to expand their funding sources (both at home and abroad) and to adjust prices of their services more independently. As a result, banks' reliance on Bank of Japan credit declined significantly, along with the Bank's leverage in using window guidance or other administrative controls to affect bank behavior.

The development of Euroyen and CD markets in recent years has been particularly important in this process (Table 3). Both markets, free from official controls, have expanded dramatically: Euroyen liabilities have grown more than fourfold and outstanding CDs more than doubled since 1985. Currently, they represent nearly half of Japanese money markets and exceed the size of domestic interbank markets

The increased availability of market-priced assets extends beyond the financial sector Investments in instruments with market-determined interest rates by the private nonfinancial sector have risen significantly, particularly since 1984, when bank deposit rates began to be liberalized (Table 4)

The rising share of market-priced instruments in portfolios has undoubtedly increased the importance of interest rates in expenditure decisions. Moreover, potential disintermediation between administered and market-priced assets has weakened the Bank of Japan's ability to transmit policy by altering spreads between interbank rates and (administered) loan and

[15]Corporate issues of securities, which accounted for roughly 10 percent of the funds raised by the corporate sector before 1973, rose close to 15 percent over 1975-79, and in recent years have risen to more than a third of corporate fund raising

Table 2

Funds Intermediation in Japan

(Fiscal Year Average)

	1965-74	1975-84	1985-90
Total funds supplied (trillions of yen)	20 4	58 6	122 91
Composition (percentage of total)			
Funds raised by domestic sectors	92 1	89.1	72 3
Loans from domestic banks	70 2	54 6	47 5
Securities	19 2	32 0	19 7
Government bonds	12 9	26 6	7 2
Foreign funds	2 7	2 5	5 1
Funds supplied to overseas market	7 9	10 9	27 7

Sources "Flow of Funds in Japan in 1990," Bank of Japan Research and Statistics Department, Special Paper no 204, July 1991, "Flow of Funds in Japan in 1989," Bank of Japan Research and Statistics Department, Special Paper no 191, August 1990

Table 3

Major Japanese Money Markets

(Trillions of Yen, End of Period Data)

	1975	1980	1985	1989
Interbank market				
Domestic interbank yen liabilities	6 7	9 8	19 8	45 3
Euroyen interbank liabilities	—	2 5	9 9	41 8
Open markets				
Bond gensaki	1 8	4 5	4 6	6 3
CDs	—	2 4	9 7	21 1
Commercial paper	—	—	—	13 1
Total	8 5	19 2	44 0	127 6
Memo				
Domestic interbank market as a share of total money markets (percentage points)	78 9	51 0	45 0	35 5

deposit rates. Comparing interbank interest rates with two rates subject to administrative control—time deposit and loan rates—during three episodes of monetary tightening provides evidence of the reduced importance of this channel (Chart 2). In both 1973-74 and 1979-80, wide differentials opened between overnight call rates and administered loan and deposit rates when policy tightened. However, in 1990, the most recent episode of tightening, spreads between these rates remained roughly unchanged.

Recent structure of the monetary control mechanism

In response to these developments, the Bank of Japan has gradually moved away from a control mechanism aimed at regulating the quantity of bank credit. Instead, it has increasingly sought to affect expenditure decisions through operations designed to affect market interest rates. The current policy control mechanism, outlined in Chart 3, shows a dramatic change from the mid-1970s.

On the level of policy instruments, the shift away from bank credit is reflected in the elimination of controls that directly affected banks' abilities to extend credit. In particular, window guidance, in the form of Bank of Japan instructions to individual banks regarding lending plans, was ended in 1982, and at about the same time, the active use of reserve requirements as a policy tool was dropped.[16] As shown earlier, the use of interest rate controls as a means of rationing credit has also slowly diminished, particularly following the major push towards deregulating bank loan and deposit rates begun in 1985.

The Bank of Japan has replaced these instruments with activities outside the interbank market. It has undertaken operations in short-term government bills (1981), CDs (1986), gensaki (1987), and commercial paper (1989). Although operations outside the interbank market have increased in frequency in recent years, the Bank of Japan continues to rely largely on its lending policies and operations in interbank markets to alter reserves.

Along with the reserve progress ratio, interbank interest rates remain the primary operating target of the Bank of Japan. Significant steps have been taken, however, to link interbank and other money markets more closely, a development that reflects the greater importance placed on financial prices in the monetary control mechanism. In 1979, the Bank acted to allow interbank rates to adjust more rapidly to open market conditions, and in subsequent years, it continued to reform its procedures for intervening in interbank markets. When the Bank became concerned that actions taken to lower interbank interest rates during 1987-88 were not being transmitted to money markets, it implemented a major

[16] A more limited form of window guidance, in which the Bank of Japan clarified its policy orientation and discussed aggregate lending plans with individual banks, continued after 1982 and was finally abolished in 1991.

Table 4

Financial Investments of the Domestic Nonfinancial Sector

	1975-79 Average	1984	1988	1990
Total investments (trillions of yen)	43 9	62 5	106 0	113 8
Composition (percentage of total)				
Assets with market-determined interest rates	30 0	50.7	86 0	147 1
Bank deposits†	—	4 2	50 7	94 7
Trust and insurance deposits	15 8	23 2	32 8	25 7
Domestic securities	12 6	13 4	−5 1	16 9
Foreign credits	1 6	9 9	7 6	9 8
Assets with regulated interest rates‡	70 0	49 3	14 0	−47 1
Memo				
		March 1984		September 1989
Bank liabilities with market-determined interest rates (share of total liabilities)		13 5		50 3

Sources: "Flow of Funds in Japan in 1990," Bank of Japan Research and Statistics Department, Special Paper no. 204, July 1991, "Flow of Funds in Japan in 1989," Bank of Japan Research and Statistics Department, Special Paper no. 191, August 1990.

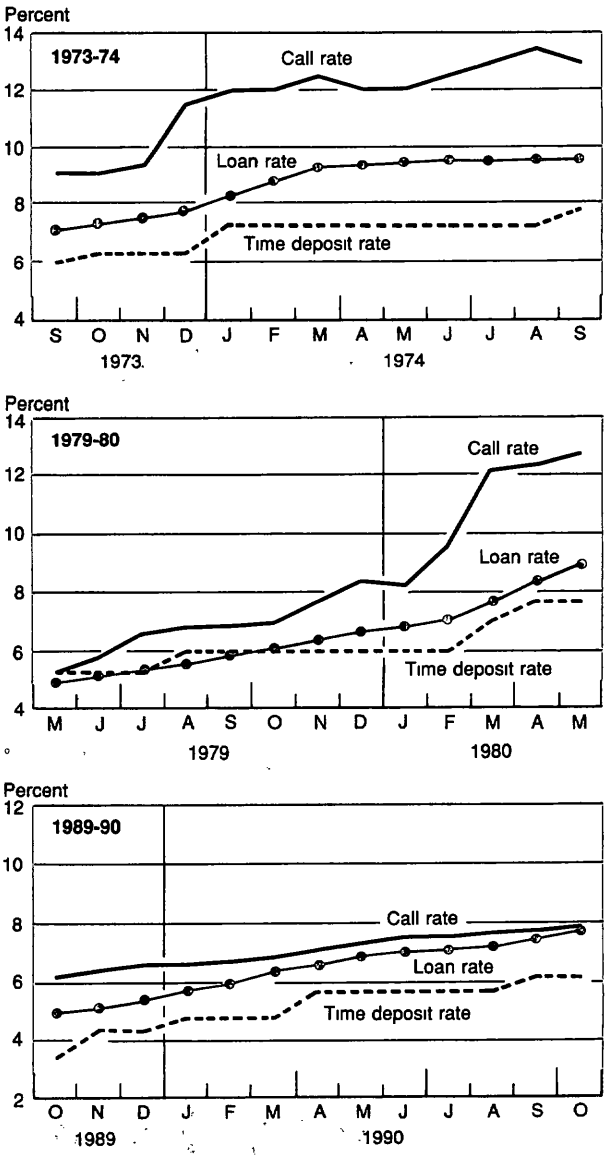
†Includes unregulated time deposits, certificates of deposit, and money market certificates.
‡Includes currency, demand deposits, regulated time deposits, postal savings deposits, and trust fund bureau deposits.

set of interbank market reforms in November 1988.[17] These reforms involved shifting interbank operations to shorter maturities and replacing the quotation system in the interbank market by an offer-bid system to promote greater arbitrage between markets.

[17]For details on the evolution of Bank of Japan operations in interbank markets, see Toshihiko Fukui, "Recent Developments of the Short-Term Money Market in Japan," Bank of Japan Research and Statistics Department, Special Paper no 130, January 1986 and Nakao and Horii, "Changes in the Monetary Control Techniques"

Chart 2

Interest Rate Movements during Periods of Monetary Tightening



Source: Bank of Japan, *Economic Statistics Monthly.*

The change in Japan's monetary control methods over the past fifteen years is most evident in the use of financial variables in the intermediate stage of the policy process. As early as 1975, the Bank of Japan began its shift away from bank credit as an intermediate target and increased its emphasis on the role of broad money in its policy operations. In a sense, credit and money targets had been equivalent up until this time because of their close relationship on bank balance sheets But with the large-scale flotation of government bonds, substantially underwritten by banks, the channels of money creation were no longer limited to increases in lending. Money thus became viewed a better indicator of levels of aggregate expenditure and assumed a leading role in the monetary control mechanism.

The Bank probably never actively employed broad money (M2+CDs) as an intermediate target, however. Instead, broad money became the primary indicator among a group of financial variables that provided information on activity and the stance of policy[18] Indeed, the Bank of Japan refrained from setting explicit targets for broad money and instead chose to publish quarterly forecasts for M2+CDs from 1978 onward.

By the mid-1980s, financial liberalization had begun to blur the boundaries of specific financial assets in Japan The wealth-holding properties of bank liabilities in the form of CDs or deregulated time deposits were enhanced, while the liquidity characteristics of securities packaged in the form of trust and insurance fund accounts increased The removal of controls on international capital movements furthered these trends because investors were able to treat assets issued in Japan or in foreign markets more interchangeably

In recent years, the Bank of Japan has responded to these developments by gradually reducing its emphasis on broad money in implementing policy. The diminished importance of broad money was highlighted in 1987 when M2+CDs grew above Bank of Japan forecasts for three consecutive quarters without provoking a policy response.

Although several variables, including exchange rates and asset prices, have been employed along with broad money as key intermediate variables over the past decade, market interest rates have become increasingly

[18]For studies supporting this view, see Michael M Hutchinson, "Japan's 'Money Focused' Monetary Policy," Federal Reserve Bank of San Francisco *Economic Review*, Summer 1986, pp 33-46, Koichi Hamada and Fumio Hayashi, "Monetary Policy in Postwar Japan," in Albert Ando, Hidekazu Eguchi, Roger Farmer, and Yoshio Suzuki, eds , *Monetary Policy in Our Times* (Cambridge MIT Press, 1985), and Shigehara, "Japan's Experience with Use of Monetary Policy"

central for policy operations. Market interest rates are an indicator of economic conditions and help to transmit interbank rate movements to real activity Concerns that actions in interbank markets were not strongly connected to other open market rates prompted reforms in the interbank market in 1988. Moreover, in 1989 and 1990, the Bank of Japan consistently cited the rising level of market interest rates as a motivation for tightening monetary policy.[19]

Monetary control of interest rates and broad money: empirical evidence

We have seen that financial liberalization has led to significant changes in the Bank of Japan's operating strategy Market-determined financial prices, interest rates in particular, play a more important role as both a target and an indicator of policy In contrast, attempts to control bank credit or other financial aggregates have gradually diminished.

While financial market changes have increased the attention given to interest rates in policy formulation, they may also have made interpretation and control of interest rates more complex In the 1970s, market segmentation and restrictions on portfolio activities ensured that central bank actions would result in a predictable pattern of substitution between the interbank market and the gensaki money market. In the current environment, agents have a greater choice of money market instruments (both domestic and foreign) and can more easily move between these instruments and long-term securities. These linkages may produce a closer connection among interest rates Nevertheless, they allow interest rates to be influenced by a wider variety of factors, a possibility that can undercut the ability of monetary authorities to influence interest rates in a predictable way.

For similar reasons, the usefulness of monetary aggregates in the monetary control mechanism may now be limited. The role of M2+CDs as an indicator of activity was largely tied to restrictions that made it the principal means of liquidity in the Japanese economy. In this environment, M2+CDs tended to reflect activity fairly closely As the wealth-holding properties of M2+CDs and liquidity characteristics of other financial assets have increased, all financial aggregates may have become less accurate indicators of activity because their short-run behavior has become sensitive to movements in relative rates of return. Moreover, as the lines between financial assets have become blurred, policy changes affecting general economic conditions or interest rates may have a weaker link to any specific aggregate, particularly in the short term.

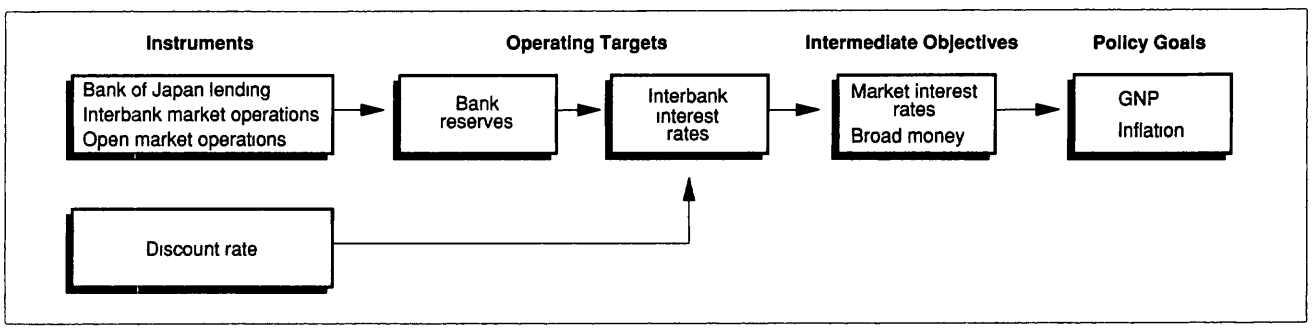
In this section, we assess the Bank of Japan's ability to transmit policies to financial market variables in the current liberalized financial market environment. Specifically, we examine the relationship between movements in interbank interest rates, the Bank's main operating target, and the intermediate variables viewed as key in the monetary control mechanism market interest rates and broad money M2+CDs

Our earlier discussion suggested that by the mid-1980s financial liberalization had caused significant changes in the functioning of Japanese financial markets Thus we focus our attention on the post-1984 experience to assess how closely Bank of Japan actions are being transmitted to interest rates and monetary aggregates in a liberalized environment. In addition, this period is contrasted with 1974-84 to provide insight into changes in these relationships over time

[19]See Nakao and Horii, "Changes in the Monetary Control Techniques," for a more detailed discussion of the factors determining monetary policy changes during the 1980s

Chart 3

Japan's Monetary Control Mechanism: Late 1980s



Econometric analysis

Our econometric analysis, explained in greater detail in the appendix, attempts to integrate short-term relationships among Japanese interest rates and monetary aggregates with models governing their longer term behavior This empirical strategy is motivated by the tendency of all the variables analyzed to drift over time without converging toward a unique long-term level.

Although interest rates and monetary aggregates may drift, economic theory suggests that common underlying factors may determine their movement. The expectations theory of the term structure, for example, suggests that long-term interest rates approximately equal an average of current and expected future short-term rates. Thus, if short-term interest rate changes are persistent (because of permanent changes in inflationary expectations or real interest rates), these changes should be reflected across the term structure Similarly, common factors may explain the evolution of broad money and the monetary base. Interest rates may also be an important part of this relationship if the sources of persistent interest rate changes have a systematic effect on broad money independent of changes in the monetary base.

The first part of our analysis searches for links between Japanese interest rates or monetary aggregates and interbank interest rates The resulting "cointegrating" regressions describing these links capture the long-term response of variables to those persistent changes in monetary policy indicated by sustained changes in the interbank call rate

Unfortunately, the regressions do not provide information on these linkages at a horizon relevant to the workings of monetary policy. Thus, the second part of the analysis develops a model of the dynamic response of interest rates and monetary aggregates to changes in the call rate consistent with these cointegrating relationships.

Before turning to our statistical analysis, we present in Table 5 some descriptive evidence on interest rates, broad money, and economic activity.[20] Specifically, the table shows mean levels of monthly interest rates and twelve-month changes in M2+CDs, consumer prices, and industrial production, along with standard deviations for the periods 1975-84 and 1985-90.

Substantial declines in both the level and the variability of money market interest rates are apparent since 1984 Over 1985-90 money market interest rates averaged roughly 5 to 5½ percent, 200 basis points below their 1975-84 levels Their variability, as measured by the standard deviation, declined by roughly one-third.

[20]The data in this section are drawn from various issues of Bank of Japan, *Economic Statistics Monthly*, and include the unconditional call rate (month end), the bond repurchase—or gensaki—rate (month end), the benchmark government bond rate (month end), the bank certificate of deposit rate (80-179 days, month average), the average rate on short-term bank loans (month end), the rate on one-year time deposits (month end), the monetary base (month end, seasonally adjusted by the authors), and M2+CDs (seasonally adjusted, month end)

Table 5

Descriptive Statistics for Economic Activity and Interest Rates

(Period Averages)

	1975-84		1985-90	
	Mean	Standard Deviation	Mean	Standard Deviation
Money market rates				
Interbank call rates	7.1	2 2	5 1	1 5
Gensaki rates	7 2	1 9	5 2	1 3
Certificate of deposit rates†	7 6	1 7	5 6	1 3
Regulated rates				
Short-term loans	6 8	1 2	5 1	1 1
Short-term time deposits	4 1	0 9	2 5	0 8
Long-term government bonds	7 9	1 1	5 4	1 2
Growth in broad money (M2 +CDs)‡	10 5	2 6	10 0	1 6
Economic activity				
Industrial production growth‡	3 7	6 6	4 5	3.7
Consumer price inflation‡	5 6	3 5	1 4	1 2

†Because certificates of deposit were not introduced until 1979, the values in the first two columns are averages for 1979-84
‡Twelve-month percentage changes

These declines are consistent with overall macroeconomic developments. Japanese consumer price inflation averaged less than 1½ percent over 1985-90, a drop of more than 4 percentage points from its 1975-84 average. Moreover, a sharp fall in the variability of consumer price inflation, broad money growth, and industrial production growth since 1985 suggests that economic activity has become considerably more stable in recent years.

Interest rates on other financial assets have also declined but, in contrast to money market rates, exhibit no significant change in their variability. From 1975 to 1984, loan and deposit rates as well as long-term bond yields were considerably less variable than money market rates. The lower variability in these rates probably reflected restrictions limiting their responsiveness to market conditions. Although financial liberalization has undoubtedly allowed these rates to adjust to changing market conditions, overall economic conditions appear to have become more stable. As a result, the effects of liberalization are seen not in the increased variability of these interest rates but rather in a convergence in interest rate variability throughout the economy.

Long-term relationships

The results of three tests for common trends, or cointegrating relations, between the overnight call money interest rate and various other interest rates are presented in Table 6 along with parameter estimates for specific equations. These tests detect whether a single underlying factor explains the drift in the regression variables (see appendix).

Overall, this evidence indicates that the linkages between the Bank of Japan's operating target and money market interest rates have been quite strong throughout the 1974-91 period. The call rate appears to have been cointegrated with both the gensaki rate and the CD rate during 1974-84 and 1985-91. During the earlier period, a 100 basis point increase in the call rate was associated with a roughly equal change in the gensaki rate. In the later period, the response of the gensaki rate was somewhat smaller, estimated at 82 basis points.

In contrast, neither loan rates nor long-term government bond yields were cointegrated with the call rate between 1974 and 1984. This result is consistent with our earlier contention that administrative controls on loan rates and restrictions on the development of a secondary market in long-term government bonds may have partially isolated these markets from interbank and short-term money markets.

Financial liberalization does appear to have integrated long-term bond markets and money markets. Between 1974 and 1984 the call rate did not have a consistent long-run connection to government bond yields. After 1984, however, strong evidence of a cointegrating relation between long-term bond yields and call rates emerges: long-term bonds increase by 69 basis points in response to a 100 basis point rise in the call rate.

There is little evidence, however, that financial reform has tightly integrated money markets with loan markets. Although the loan rate reacted more strongly to call rate changes after 1984, bank loan rates were not cointegrated with the call rate between 1985 and 1991, suggesting that there has not been a consistent long-term relation between the rates.

Table 6

Cointegration Relationships for Monthly Interest Rates

Response to Call Rate of	1974-84	1985-91†
Gensaki	1.00	.82
R^2	84	97
Cointegration tests		
ADF	−3.28*	−2 71
SW	−51.67***	−33.90***
PP	−32 37***	−44.20***
CD‡	90	.85
R^2	.97	.96
Cointegration tests		
ADF	−2.97	−2.42
SW	−29.75***	−35.26***
PP	−25.22**	−43.33***
Long-term bond	.34	69
R^2	.65	.83
Cointegration tests		
ADF	−1.78	−3.33*
SW	−10.82	−23.77***
PP	−12.42	−20.79**
Loan rate	49	.73
R^2	.75	.88
Cointegration tests		
ADF	−2.40	−1.33
SW	−7.87	−9.62
PP	−5.98	−11 14

Notes: ADF is the augmented Dickey-Fuller statistic (using seven lags). PP is the Phillips-Perron Z_α statistic (using seven autovariance lags). SW is the Stock-Watson statistic (using seven lags). Critical values for the Dickey-Fuller and Phillips-Perron statistics were obtained from P.C.B Phillips and Sam Ouiliaris, "Asymptotic Properties of Residual-Based Tests for Cointegration," *Econometrica*, vol. 58, no. 1 (January 1990), pp 165-91 Critical values for the Stock and Watson statistic are from James Stock and Mark Watson, "Testing for Common Trends," *Journal of the American Statistical Association*, vol. 83 (December 1988), pp. 1097-1107.

†Sample covers January 1985-May 1991.
‡Earlier sample covers 1980-84.
*Significant at 10 percent level.
**Significant at 5 percent level.
***Significant at 1 percent level.

Our model connecting monetary policy actions to broad money is based on a standard view of the money supply process.[21] Bank of Japan operations in interbank markets are accompanied by changes in both reserves available to the banking system and interbank interest rates. Given unchanged asset allocations by banks and depositors, changes in reserves can be expected to alter broad money (M2+CDs) in a predictable manner Interest rate movements can alter portfolio choices, thus influencing the money supply independently of changes in the monetary base. Higher market interest rates, all else equal, raise the cost of holding bank reserves and consequently may increase the money multiplier (the ratio of broad money to the monetary base) At the same time, an increase in central bank lending rates or interbank rates relative to market rates could increase demand for reserves and thus lower the money multiplier. We suggested earlier that Bank of Japan actions associated with higher interbank interest rates, including window guidance and changes in reserve requirements, may have reinforced a decline in the money multiplier in the past.[22]

Nonetheless, interest rate effects on the money multiplier might be transitory, particularly because regulatory restraint on bank behavior was applied only temporarily Thus, we first model the longer term behavior of M2+CDs as a function of the monetary base alone, including a time trend term to allow for technological factors that may have altered the money multiplier over time

The cointegrating regressions for this model, presented in the upper half of Table 7, provide no evidence of a cointegrating relation between the base and M2+CDs before 1985 This result suggests that factors leading to persistent movements in the money multiplier were an important determinant of the long-term behavior of broad money during this period In contrast, between 1985 and 1991, evidence of a cointegrating regression is present, and thus money base changes, through a stable multiplier, adequately explain the long-term evolution of M2+CDs

To assess whether the persistent movement in the money multiplier before 1985 was associated with interest rate movements, we add the call and gensaki rate to our regression model In this context, the gensaki rate captures alternative bank investment opportunities that became available beginning in the second half of the 1970s. Call rate movements measure the cost of reserve shortfalls to banks and also proxy for the effects of policy actions not related to changes in the monetary base The coefficient on the monetary base is restricted to equal one in this framework because, by definition, base changes are fully reflected in the money supply when the multiplier is unchanged.

Including interest rates in the model yields strong evidence of cointegration for the 1974-84 period Moreover, the parameter estimates are of the correct sign and suggest a large effect of call rate changes on broad money. Specifically, when market rates and the monetary base are held constant, a 100 basis point increase in the call rate is associated with a permanent decline of nearly 2 percentage points in M2+CDs.

Nevertheless, these call rate effects decline substantially after 1984. Indeed, the small size of the interest

[21] Money demand is also important in money stock determination Because we do not explicitly model money demand, our analysis should not be viewed as a full behavioral model for the determination of interest rates and the money stock

[22] In particular, Japanese banks were forced to constrain lending activities when policy tightened because loan rates were regulated and the Bank of Japan imposed quantitative restrictions on lending These restrictions, together with the Bank's active use of reserve requirement changes to implement monetary policy, forced banks to increase their reserve-deposit ratios as policy tightened, an outcome that lowered the money multiplier and broad money for a given monetary base

Table 7
Cointegrating Money Models

Response of M2+CDs to	1974-84	1985-91†
ln (base)	554	412
Trend	005	005
R^2	993	998
Cointegration tests		
ADF	−2 091	−3 138
SW	−8 174	−36 469***
PP	−6 212	−45 227***
Response of M2+CDs to		
ln (base)	1 000‡	1 000‡
Gensaki rate	009	007
Call rate	− 019	− 004
Trend	002	000
R^2	997	993
Cointegration tests		
ADF	−2 342	−2.324
SW	−39 704***	−45 738***
PP	−49 081***	−56 650***

Notes: R^2 is the square of the correlation coefficient between actual and predicted *ln* (M2) for the two regressions with base coefficients equal to one ADF is the augmented Dickey-Fuller statistics (using seven lags) PP is the Phillips-Perron Z_α statistic (using seven autovariance lags) SW is the Stock-Watson statistic (using seven lags) Critical values for the Dickey-Fuller and Phillips-Perron statistics were obtained from Phillips and Ouliaris, "Asymptotic Properties of Residual-Based Tests " Critical values for the Stock and Watson statistic are from Stock and Watson, "Testing for Common Trends "

†Sample covers January 1985-May 1991
‡Constrained to equal 1
*Significant at 10 percent level
**Significant at 5 percent level
***Significant at 1 percent level

rate coefficients in the money supply equations suggests that interest rate movements, independent of the monetary base, may no longer have any lasting effect on broad money.

Dynamic relations

The evidence of long-term linkages between call rates and other financial variables does not, by itself, clarify how monetary policy changes are transmitted over a horizon relevant for policy makers. To address this question, we estimate a dynamic error-correction model for Japanese financial market variables. The model, presented in detail in the appendix, captures in a fairly unrestricted way the observed time series relationships among these variables by imposing the condition that the dynamic behavior converge to the long-term cointegrating regressions estimated above

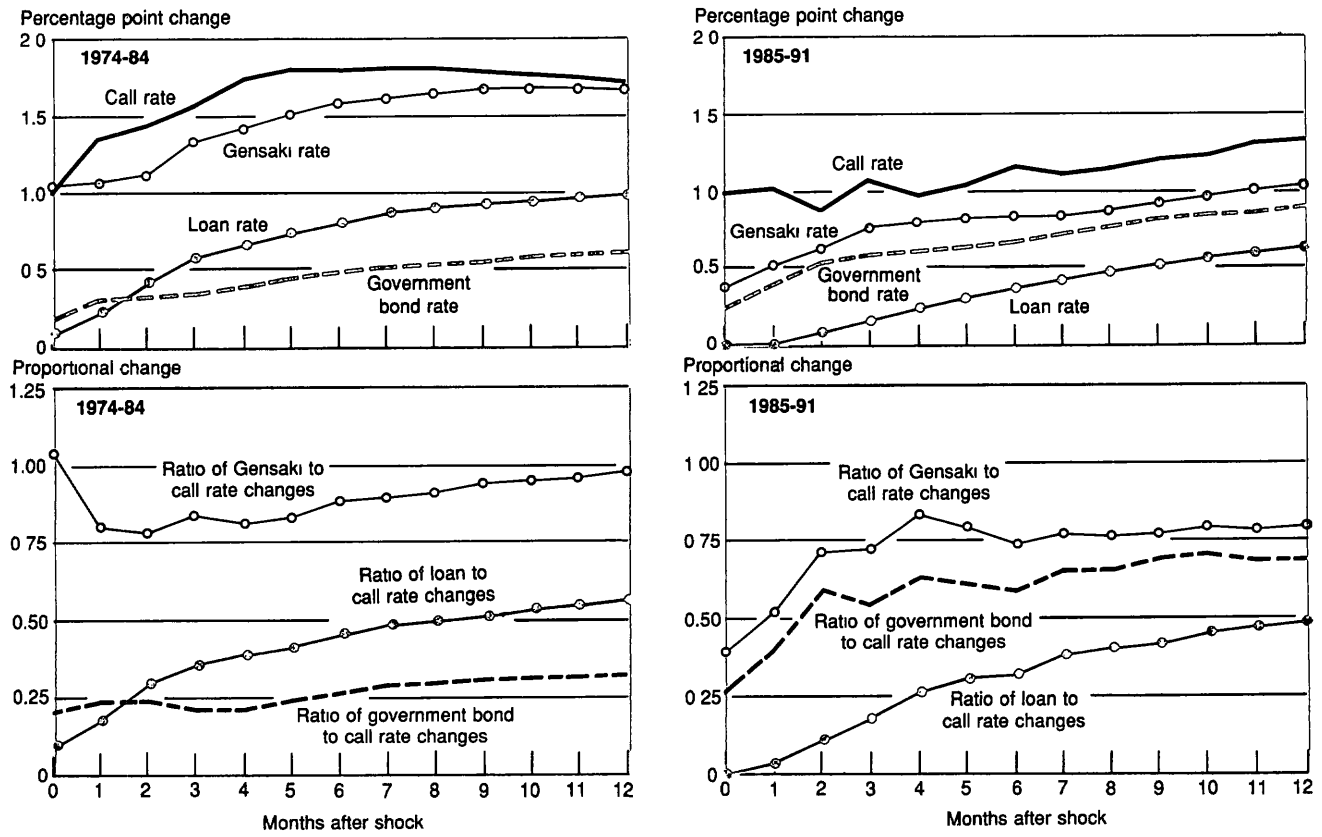
Assuming that the Bank of Japan has considerable control over the interbank call rate, we use the model to assess the monetary control mechanism by comparing the responses of interest rates and broad money to an initial 100 basis point increase in the call rate.[23] These responses, presented in Charts 4 and 5, can be interpreted as the average response of interest rates and broad money to policy changes over the sample. The simulations also track subsequent call rate movements generated by the model, these movements capture the tendency of Bank of Japan policy shifts to occur gradually as well as the typical response of call rates to changes in other financial variables.

The evidence in Chart 4 suggests somewhat stronger transmission of call rate shocks to interest rates after

[23]Although the results of this analysis are presented separately for interest rates and monetary aggregates, they are derived from a single model that accounts for the interrelationship among these variables

Chart 4

Interest Rate Responses to a Call Rate Increase



Note: Chart shows the predicted response to an increase of 100 basis points in the call rate

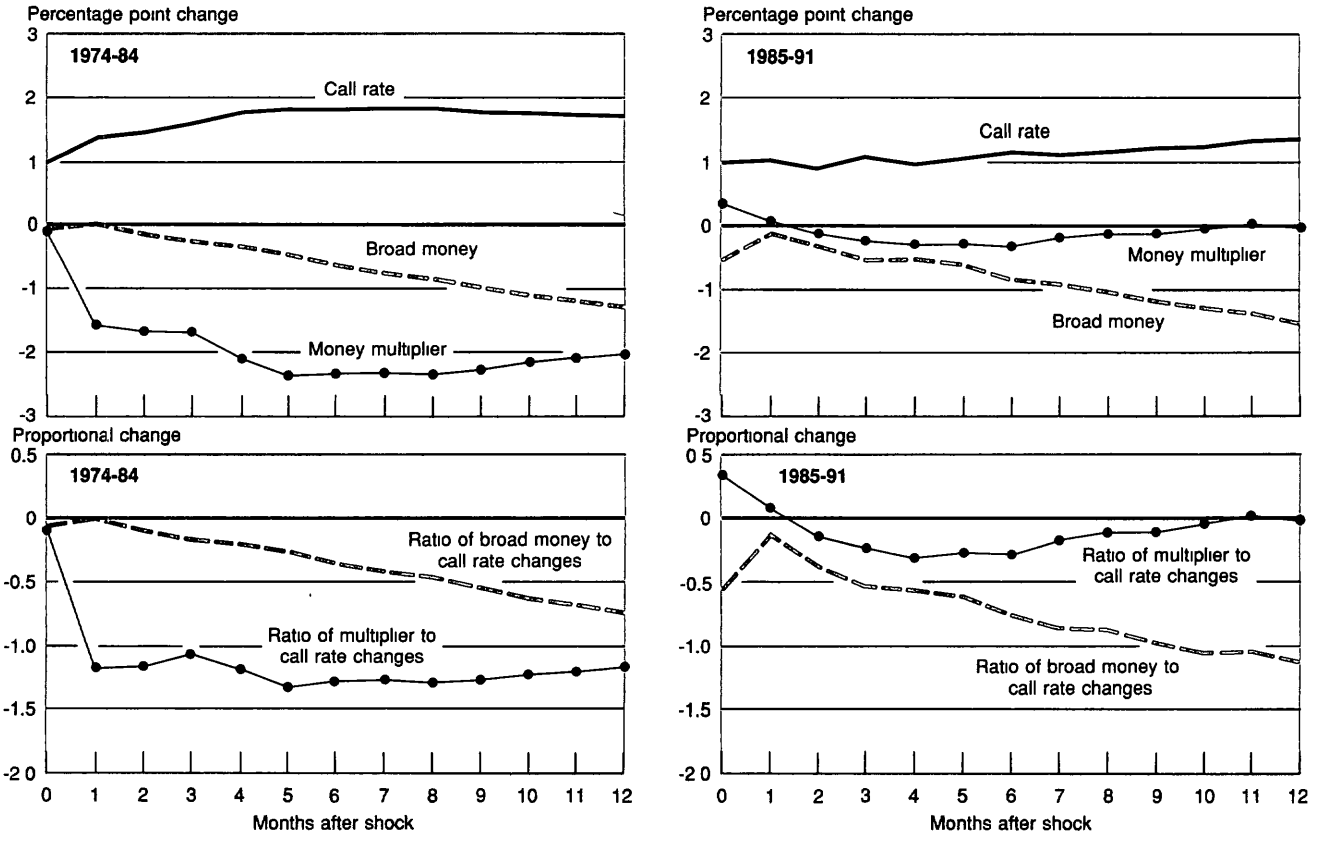
1984, primarily because of the increased responsiveness of long-term bond yields. From 1975 to 1984 only the gensaki rate responded strongly and immediately. a 100 basis point increase in the call rate prompted an immediate and equal rise in the gensaki rate In contrast, the immediate responses of long-term bond yields and loan rates were quite small Three months following the shock only about one-third of the cumulative increase in call rates had been passed through to loan rates, and less than one-fourth of this increase was transmitted to bond yields. Over time, loan rates continued to rise, in part reflecting administrative decisions by the Bank of Japan. But even after a year only about one-third of the call rate increase was reflected in long-term bond yields.

During 1985-91, the gensaki rate responded more slowly to the call rate shock, rising about 40 basis points at the time of the shock. Nonetheless, three months after call rates increased, the response of the gensaki rate was close, in proportional terms, to both its estimated long-term response and that observed in the earlier period. Long-term bond yields, in contrast, reacted much more strongly to call rate shocks after 1984 Three months after the initial shock, nearly 60 percent of the call rate shock was passed through to bond yields, a response nearly three times as great as during the earlier period. The loan rate response showed little change across the two periods

Simulation results for broad money and the money multiplier in Chart 5 support the view that the money multiplier was an important part of the policy transmission mechanism before 1985. In the 1974-84 period, increases in the call rate caused a sharp fall in the money multiplier. In the first three months following a call rate increase, the multiplier declined by nearly 2 percent, indicating large portfolio shifts by banks

Chart 5

Response of Broad Money and Money Multiplier to a Call Rate Increase



Note Chart shows the predicted response to an increase of 100 basis points in the call rate

The immediate effect of a call rate increase on broad money was quite small, but over time, broad money steadily declined At three months, broad money fell by about .4 percent; a year after the shock, broad money declined by more than 1 percent.

During 1985-91, the response of broad money to a call rate increase has been roughly similar to that seen in the earlier period. Nonetheless, the channel of transmission appears to have changed dramatically Call rate movements no longer alter the money multiplier, which remains roughly unchanged over the forecast horizon Thus, monetary policy influences broad money through its effect on the supply of reserves rather than through its influence on bank asset allocation.

Predictability of dynamic responses

To assess monetary control, we must consider not only the size of the response of financial market variables to policy but also the predictability of these responses. Evidence on predictability of responses can be obtained by computing the forecast standard errors of our variables at different horizons These standard errors, presented in Table 8, indicate the degree to which the actual responses of financial variables to interbank rate movements are likely to fall near the estimated responses presented in Charts 4 and 5.[24] In computing these standard errors, we have excluded the uncertainty attributable to fluctuations in call rates In our framework, call rate movements represent monetary policy actions, and these estimates should capture the uncertainty in financial market variables arising from factors other than monetary policy.[25]

The estimated forecast variances for interest rates present a mixed picture. Standard errors for the gensaki rates declined substantially after 1984, possibly reflecting the emergence of more stable economic conditions In contrast, the standard errors for long-term bond yields and loan interest rates showed little or no

[24]Note that these forecast standard errors only represent the uncertainty arising from unpredictable shocks affecting the system In computing the standard errors, we ignore uncertainty due to imprecision in our coefficient estimates Thus, the forecast standard errors in Table 8 probably underestimate the total uncertainty surrounding these responses

[25]Despite this adjustment, a comparison of forecast variances for 1974-84 and 1985-91 is likely to be influenced by changing policy objectives as well as changes in the general degree of economic stability

Table 8

Predictability of Response to Call Rate Increases

		Forecast Standard Error† (Percentage Points)	
	Months after Shock	1974-84	1985-91
Gensaki rate	3	68	38
	6	92	55
	12	1 39	81
Long-term bond rate	3	57	63
	6	72	72
	12	98	92
Loan rate	3	21	20
	6	37	41
	12	65	80
M2+CDs	3	1 45	1 61
	6	2 56	2 79
	12	4 97	5 53
Monetary base	3	2 11	2 16
	6	2 98	3 06
	12	5 18	5 55
Money multiplier	3	1 74	1 65
	6	1 91	1 67
	12	2 18	1 71

Notes The forecast standard errors are derived for three-, six-, and twelve-period-ahead forecasts conditional on a predetermined call rate path Our calculation uses the unconditional forecast standard error and subtracts the portion due to call rate shocks

†Excludes fraction of variance attributable to call rate changes

systematic change, with the possible exception of increased uncertainty attending loan rate responses at longer horizons

The small pre-1985 standard errors for bond yields and loan rates reflect the restrictions on rate movements in effect at the time. As liberalization has proceeded, gensaki and other rate forecast errors have converged. Together with the decline in gensaki forecast errors, this evidence suggests that the Bank of Japan has been able to influence the broad spectrum of market-determined interest rates with somewhat greater certainty

The forecast standard errors for monetary aggregates unambiguously point to greater uncertainty for the estimated responses after 1984 Both broad money and the monetary base responded less predictably to call rate changes, despite evidence of a more stable economic environment. This increased uncertainty in broad money responses may in part reflect the declining use of monetary aggregates in policy determination

Conclusions

We have argued that the substantial liberalization of Japan's financial system has profoundly affected both the functioning of the Japanese economy and the conduct of monetary policy by the Bank of Japan The tightly restricted financial system in the mid-1970s promoted a monetary policy strategy that used bank credit to influence activity. Financial liberalization has, however, reduced the importance of banks in Japan's flow of funds and eliminated a number of policy tools that restricted bank behavior. In response, the Bank of Japan has gradually become more dependent on its ability to influence market interest rates to transmit its policies.

Our analysis of the monetary control mechanism suggests that in the current liberalized environment, the Bank of Japan has been able to transmit its policies effectively through market interest rates. In particular, interbank interest rate movements, the key operating targets of the Bank of Japan, have produced strong and consistent interest rate responses across the Japanese term structure since 1984. The increased responsiveness of long-term bond yields in recent years is particularly notable. Moreover, some evidence suggests that the linkage between policy and interest rates has become more predictable.

In contrast, the linkage between monetary policy and broad money has probably weakened In the past, policy actions were largely transmitted to broad money through the money multiplier as the Bank of Japan directly influenced banks' portfolio decisions. Now, however, financial liberalization has reduced the Bank of Japan's leverage over bank behavior, and policy's influence on broad money works more closely through changes in the monetary base. Although the average response of broad money to policy changes remains about the same, a greater degree of uncertainty accompanies the transmission of policy to broad money.

Appendix: Cointegrating Money and Interest Rate Models

This appendix expands on the arguments in the text for cointegration between interest rates and for cointegration in the money supply relation It also presents the dynamic error correction models used to predict the responses of interest rates and monetary aggregates to monetary shocks.

Cointegration

To investigate the relation between Japanese interest rates and monetary aggregates, we utilize the cointegration methodology made popular by Engle and Granger.[†] This methodology presupposes that a time series containing a unit root can only be explained over long periods by other series with a unit root Series with a unit root (also called integrated series) are predicted well by their own lagged values Typically, regression models for this type of series have substantial residual autocorrelation because other variables cannot explain the unit root component in the outcome variable

Testing for a unit root in a time series, r_t, is commonly carried out by testing whether the coefficient in a regression on r_{t-1} equals one. The literature uses tests based on the coefficient α in the regression $\Delta r_t = \alpha r_{t-1}$. The coefficient will be zero if the series has a unit root and negative otherwise (unless the series is explosive) The augmented Dickey-Fuller test uses the t-statistic for α in the regression, adding lagged changes in r_t to account

[†]See Robert Engle and C W J Granger, "Co-integration and Error Correction Representation, Estimation, and Testing," *Econometrica*, vol 35 (1987), pp 251-76

Appendix: Cointegrating Money and Interest Models *(continued)*

for possible stationary autocorrelation in r_t. The Stock-Watson statistic, as used in this article, is based on filtering r_t to eliminate stationary autocorrelation before computing the t-statistic The Phillips-Perron statistic, Z_α, corrects for stationary autocorrelation by applying a non-parametric correction to $T\alpha$, where T is the sample size. In each case, the distribution of the test statistic is nonstandard and requires specially calculated critical values.

Several series with unit roots may be linked through a cointegrating model—that is, a model whose residual does not contain a unit root The regressors in this type of model explain the permanent or unit root component of the dependent variable. Although the variables in the regression may deviate from the regression line in the short run, they return to the regression relationship over time in the absence of additional shocks In fact, the cointegrating model does not specify the dynamic adjustment to the model in the long run This adjustment is specified by auxiliary equations in the error correction model that give the dynamic behavior of the variables.

The error correction models are a series of dynamic equations relating the current change in each variable in a cointegrated system to the lagged residual from the cointegrating model and to lagged changes in the variables The coefficient of the lagged residual in our models measures the speed of adjustment to long-run equilibrium Lagged changes appear as explanatory variables in the models to allow variables to have differing short-term effects

Thus, we carry out a two-step procedure in our empirical work. First, we test the time series for the presence of a unit root. If a unit root is found, we proceed to test for cointegration between those sets of series that could, in theory, be linked. The unit root tests are shown in Table A1 and the cointegration tests are discussed in the text of the article Second, we use the cointegrating equations to formulate an error correction model for the dynamics in the model. This error correction model, examined in more detail below, is used to compute the impulse response functions reported in the text.

Cointegration in interest rate and money models

The expectations hypothesis of the term structure provides one model where short and long rates will be cointegrated ‡ We assume the existence of the following (approximate) relationship connecting short- and longer term asset returns

$$(A.1)\quad r^l(1,D) = (1/D)\,[r^s(1,2) + f(2,3) + \ldots + f(D-1,D)],$$

where $r^l(1,D)$ is the yield to maturity, in D periods, of the longer term asset, $r^s(1,2)$ is the return from period one to two on the shorter term asset, and $f(j,j+1)$ is today's forward rate between periods j and $j+1$. The expectations hypothesis connects the forward rate from j to $j+1$ to the expected future spot rate from j to $j+1$ as follows

$$(A\,2)\quad f(j,j+1) = E_t\, r^s(j,j+1) + \alpha(j),$$

where α is a risk premium and E_t represents expectations at period one Finally, we suppose that the short rate follows a simple random walk.

$$(A\,3)\quad r^s(j+1,j+2) = r^s(j,j+1) + e(j+1),$$

where e is the unexpected component of the short rate. Since expected future short rates will be directly related to the current spot rate, $E_t r^s(j) = r^s(1)$, the current long rate will follow·

$$(A\,4)\quad r^l(1,D) = r^s(1,2) + (1/D)\,\Sigma\alpha(j)$$

Table A1: Unit Root Tests

(Monthly, January 1974 to May 1991)

Series	ADF	SW	PP
Call rate	−3 36	−14 01*	−8 72
Gensaki rate	−3 73*	−18 38**	−13 09
Long-term bond rate	−1 65	−4 45	−4 54
CD rate†	−2 34	−8 26	−8 10
Loan rate	−2 55	−9 01	−6 62
ln (M2)	−2 26	− 62	− 49
ln (Base)	− 25	− 14	− 44
ln (M2)‡	−2 81	−9 69	−5 00
ln (Base)‡	−2 21	−18 37*	−15 54

Notes ADF is the augmented Dickey-Fuller statistic (using seven lags) PP is the Phillips-Perron Z_α statistic (using seven autovariance lags) SW is the Stock-Watson statistic (using seven lags) Critical values for the Dickey-Fuller and Phillips-Perron statistics were obtained from Phillips and Ouliaris, "Asymptotic Properties of Residual-Based Tests " Critical values for the Stock and Watson statistic are from Stock and Watson, "Testing for Common Trends "

†First sample covers 1980-84
‡Includes time trend
*Significant at 10 percent level
**Significant at 5 percent level
***Significant at 1 percent level

‡See Thomas Sargent, "A Note on Maximum Likelihood Estimation of the Rational Expectations Model of the Term Structure," *Journal of Monetary Economics*, vol 5 (1979), pp 133-43, and John Campbell and Robert Shiller, "Cointegration and Tests of Present Value Models," *Journal of Political Economy*, vol 95 (1987), pp 1062-88

Appendix: Cointegrating Money and Interest Models *(continued)*

The short rate may have a unit root if it is influenced by either inflation or the real interest rate and if changes in these variables tend to be permanent Under these conditions, equation A 4 implies that the long rate should be cointegrated with the short rate. Of course, if the risk premium has a unit root, then the long rate will be cointegrated with the (measurable) short rate and the (not directly measurable) risk premium term, and we would not expect the short rate–long rate pair to be cointegrated by themselves.[§]

[§]Because we do not restrict the term spread to be stationary, our interest rate models are more general than those strictly implied by the expectations hypothesis Although some of our coefficient estimates in the cointegrating interest rate models seem far enough from one to cast doubt on the expectations hypothesis, our assets have different issuers and potentially quite different risk characteristics, complicating the risk terms in our earlier formulation

In our money model, we assume that the broad money aggregate is connected to base money through a money multiplier, $M2 = m\ Base$, where $M2$ is the broad aggregate, *Base* is base money, and m is the money multiplier. Broad money and base money would be cointegrated if the influences on bank and depositor asset allocation typically only have transitory effects on the money multiplier. To obtain a cointegrating relationship between the base and broad money during 1974-84, we find it necessary to allow for both trend and interest rate effects These modifications suggest that the multiplier has a unit root arising from trends in asset choice and permanent interest rate effects

Dynamic models

The cointegrating models in the text are incorporated into dynamic models for the call, gensaki, and ten-year

Table A2: Error Correction Models

	Dependent Variables					
Independent Variables	Call Changes	Gensaki Changes	Bond Changes	Loan Changes	M2 Changes	Base Changes
January 1974 to December 1984						
Sum of						
lagged call changes	56(28)	.35(21)	08(08)	10(04)	002(002)	.01(004)
lagged gensaki changes	− 06(09)	−1 11(43)	01(06)	05(03)	000(001)	001(003)
lagged bond changes	31(15)	57(.22)	02(21)	11(03)	−.001(002)	001(005)
lagged loan changes	28(55)	1 54(73)	− 07(24)	58(07)	− 008(006)	− 02(01)
lagged M2 changes	4 73(4 69)	2 37(0 93)	.67(3 17)	−1 06(69)	90(08)	33(18)
lagged base changes	−1 58(3 36)	3 86(4 75)	−2 36(2 09)	32(46)	− 04(05)	16(24)
Residual (gensaki)	24(09)	01(14)	− 13(06)	—	—	—
Residual (money)	1 12(2 63)	1 43(3 87)	—	—	− 06(04)	20(08)
R^2	30	22	12	87	01	26
January 1985 to May 1991						
Sum of						
lagged call changes	− 72(31)	− 18(10)	02(17)	03(05)	− 000(003)	− 002(007)
lagged gensaki changes	89(27)	39(26)	− 23(30)	02(07)	004(006)	006(013)
lagged bond changes	10(11)	06(08)	17(38)	09(03)	005(003)	006(006)
lagged loan changes	76(40)	14(36)	53(46)	82(06)	− 02(01)	009(018)
lagged M2 changes	4 84(3 77)	2 32(2 39)	3 14(4 28)	22(49)	1 08(14)	.18(.25)
lagged base changes	−2 87(2 26)	− 93(1 43)	−2 80(2 34)	− 25(27)	− 21(06)	48(32)
Residual (gensaki)	19(.18)	−.25(11)	− 24(21)	—	—	—
Residual (long-term bond)	—	13(06)	− 18(15)	—	—	—
Residual (money)	−2.69(2 49)	−1 83(1 58)	—	—	− 10(07)	60(15)
R^2	45	44	17	91	26	40

Notes Standard errors are shown in parentheses The residual for the gensaki rate is obtained from the cointegrating model connecting the gensaki and call rates, the residual for the long-term bond rate is obtained from the cointegrating model connecting the long-term government bond and gensaki rates, the residual for money is the residual from the cointegrating model for money supply

Appendix: Cointegrating Money and Interest Rate Models *(continued)*

government bond rates as well as the monetary base and the M2+CDs aggregate. Since we do not detect a long-term relationship between the loan rate and other interest rates, our cointegrating equations do not include the loan models presented in Table 6 of the text. The cointegrating, or long-run, interest rate models are

$$(A.5) \quad G = \alpha_0 + \alpha_1 C + \epsilon^G$$

and

$$(A.6) \quad L^J = \alpha_2 + \alpha_3 G + \epsilon^{L^J},$$

where C represents the call rate, G is the gensaki rate, and L^J is the Japanese benchmark long-term government bond yield.[‖] Our cointegrating equation for broad money supply relates broad money, *M2*, to the base, *Base*, the gensaki rate, G, the call rate, C, and a time trend t, restricting the coefficient on the base so that the interest rates and time trend affect the money multiplier.

$$(A\ 7) \quad ln(M2) = \kappa_0 + ln(Base) + \kappa_1 G + \kappa_2 C + \kappa_3 t + \epsilon^{M2}.$$

Our estimates of these models are given in text Tables 6 and 7.

The dynamic equations have a general error correction form that relates the current change in each variable to lagged changes in all of the variables and to the residuals from the cointegrating coregressions.[††] Estimates of these dynamic models are shown in Table A2. We typically include four lags of the dependent variable and one lag of the other variables.[§§] In most cases, we only include residuals from cointegrating equations that contain the dependent variable. The general form of the model is illustrated by the call rate equation below:

$$(A\ 8) \quad \Delta C(t) = -\delta_1 \epsilon^G(t-1) - \delta_2 \epsilon^{L^J}(t-1) - \delta_3 \epsilon^{M2}(t-1) + \sum_{i=1}^{4} \beta_i \Delta C(t-i) + \gamma_1 \Delta G(t-1) + \Psi_1 \Delta L^J(t-1) + \theta_1 \Delta Loan(t-1) + \zeta_1 \Delta lnM2(t-1) + \phi_1 \Delta lnBase(t-1).$$

The lagged residuals in this equation ensure that the short-run behavior in the dynamic model will converge to the long-run behavior embodied in equations A 5, A 6, and A.7. The lagged changes of the variables allow the short-run impacts of interest rate shocks to differ from the long-run behavior in the cointegrating equations. Analogous to the call rate equation are the equations for the gensaki rate, the Japanese long-term government bond yield, and bank loan rate given below.

$$(A\ 9) \quad \Delta G(t) = -\delta_1 \epsilon^G(t-1) - \delta_2 \epsilon^{L^J}(t-1) - \delta_3 \epsilon^{M2}(t-1) + \beta_1 \Delta C(t-1) + \sum_{i=1}^{4} \gamma_i \Delta G(t-i) + \psi_1 \Delta L^J(t-1) + \theta_1 \Delta Loan(t-1) + \zeta \Delta lnM2(t-1) + \phi_1 \Delta lnBase(t-1),$$

$$(A\ 10) \quad \Delta L^J(t) = -\delta_1 \epsilon^G(t-1) - \delta_2 \epsilon^{L^J}(t-1) + \beta_1 \Delta C(t-1) + \gamma_1 \Delta G(t-1) + \sum_{i=1}^{4} \psi_i \Delta L^J(t-i) + \theta_1 \Delta Loan(t-1) + \zeta_1 \Delta lnM2(t-1) + \phi_1 \Delta lnBase(t-1),$$

and

$$(A\ 11) \quad \Delta Loan(t) = \sum_{i=0}^{3} \beta_i \Delta C(t-i) + \sum_{i=1}^{3} \gamma_i \Delta G(t-i) + \sum_{i=1}^{3} \psi_i \Delta L^J(t-i) + \sum_{i=1}^{3} \theta_i \Delta Loan(t-i) + \zeta_1 \Delta lnM2(t-1) + \phi_1 \Delta lnBase(t-1)$$

These equations allow us to estimate the dynamic response of Japanese interest rates to shocks in the call rate (our proxy for Japanese monetary policy actions).

The dynamic error correction equations for the monetary base, *Base*, and broad money, *M2*, have the follow-

‖ The main text presents a cointegrating model connecting the government bond yield to the call rate. Our modeling strategy uses the equation A 6 connecting the bond yield and the gensaki rate as the long-term relation for the bond yield. The corresponding equations are
1974-84 L^J = 275 + 28G, R^2 = 51
1985-91 L^J = 1 01 + 84G, R^2 = 86
There is strong evidence of cointegration in the second period and essentially none in the first.

†† For details, see Engle and Granger, "Co-integration and Testing," and James Stock, "Asymptotic Properties of Least Squares Estimators of Cointegrating Vectors," *Econometrica*, 1987, pp. 1035-56.

§§ Our choice of lag structure is motivated by the autocorrelations of first differences of the data. These generally seem consistent with fourth-order autoregressive models. We include more lags of other interest rates in the loan equation to allow for possible effects over several periods.

Appendix: Cointegrating Money and Interest Rate Models *(continued)*

ing forms, in which the lagged residual is obtained from equation A.7:

$$\text{(A 12)}\quad \Delta lnM2(t) = -\delta\epsilon^{M2}(t-1) + \beta_1\Delta C(t-1) + \gamma_1\Delta G(t-1) + \psi_1\Delta L^J(t-1) + \phi_1\Delta Loan(t-1) + \sum_{i=1}^{4} \zeta_i\Delta lnM2(t-i) + \phi_1\Delta lnBase(t-1)$$

and

$$\text{(A 13)}\quad \Delta lnBase(t) = -\delta\epsilon^{M2}(t-1) + \beta_1\Delta C(t-1) + \gamma_1\Delta G(t-1) + \psi_1\Delta L^J(t-1) + \phi_1\Delta Loan(t-1) + \zeta_1\Delta lnM2(t-1) + \sum_{i=1}^{4} \phi_1\Delta lnBase(t-i).$$

To simulate the models and to compute forecast standard errors, we have to impose a structure on the current disturbances in the error correction equations. We use an ordering of the disturbances (call, base, gensaki, long-term bond, M2+CDs, loan) in which current shocks to each variable in the list affect contemporaneous shocks in variables listed later. Our ordering allows the current call rate shocks to affect shocks in all the other variables in the system. When we analyze predictability of policy responses, we remove the component attributable to call rate shocks from the forecast standard errors to exclude uncertainty related to policy changes. Although these standard errors correctly measure uncertainty when monetary policy is designed to minimize the variance of a single variable, the interpretation of the errors may be more difficult when monetary policy has multiple objectives.