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The Effect of the Increase in Monetary Base on Japan's Economy at Zero Interest Rates : An Empirical Analysis*

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Abstract

In this paper, we quantify the effect of so-called "quantitative monetary easing" which the Bank of Japan adopted in March 2001. Now that short-term interest rates are almost zero and monetary base growth is over 20 percent year on year, active debate continues with respect to the effectiveness of monetary policy at zero interest rates. Taking into account the regime change in monetary policy and the possible non-linearity of money demand at low (or near zero) interest rates, we use a Bayesian VAR, a VAR with time-varying coefficients, to extract the effect of the increase in monetary base at zero interest rates. The result of a Bayesian VAR indicates that while an increase in monetary base previously had a positive impact on prices, it does not now at zero interest rates. In order to investigate the possible reason for this result, we then estimate a money demand function, and test whether a satiation level in demand for monetary base exists at zero interest rates. The key finding here is that the null hypothesis of the non-existence of the satiation level can be statistically rejected. This means that there may remain room for an increase in monetary base to stimulate the economy at zero interest rates. Despite the existence of the satiation level of money demand, why does the Bayesian VAR result suggest that an increase in monetary base does not have a positive impact on economic activity at zero interest rates? One way to consistently interpret these two results is that the effect of the increase in monetary base is highly uncertain and very small, if any. We confirm this view by estimating models that include both aggregate demand and aggregate supply functions and testing whether monetary base enters these equations significantly. Finally, we discuss reasons why the expansion of monetary base at zero interest rates has such a limited and uncertain effect on the economy.

Keywords : Monetary Policy, Quantitative Easing, Bayesian VAR, Satiation Level of Money Demand

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1. Introduction

On March 19, 2001, the Bank of Japan introduced new procedures for money market operations under which the outstanding balance of current accounts held at the Bank, instead of the overnight call rate, is used as the main operating target. The change in the operating target was closely related to the fact that the overnight call rate had almost reached a zero bound and the Bank still needed to ease monetary policy to combat persistent deflationary pressure. The target level of the outstanding balance of current accounts held at the Bank exceeded the actual amount of February 2001. At the same time, the Bank decided that the new procedures for money market operations should continue in place until the Consumer Price Index (excluding perishables; nationwide) registers stably at zero percent or an increase year on year. The Bank also decided to increase the outright purchase of long-term government bonds if it considered such necessary to smoothly provide liquidity. Furthermore, the Bank established so-called “Lombard-type” lending facility that enables financial institutions, under certain conditions, to borrow funds from the Bank at the official discount rate as long as they have eligible collateral. This entire policy regime is often referred to as “quantitative monetary easing” measures.

The new policy regime was introduced to explore the possibility of further monetary easing even after short-term interest rates had fallen to zero. The Bank of Japan pursued this policy, while concurrently examining the following effects theoretically assumed on Japan’s economy.

First, lower interest rates would still have a stimulative impact on the economy. In this regard, the announcement that the new policy regime should be maintained until CPI inflation becomes zero or more was intended to induce maximum effects from a rather limited call rate cut on longer term rates. Second, the abundant provision of liquidity would make money market participants feel more secure about the availability of funds, thereby preserving financial market stability. Third, an increase in reserves might invite liquidity satiation and, consequently, somehow induce portfolio shifts in financial assets, resulting in, for example, a rise in stock prices, depreciation of the yen, or credit expansion. Fourth, decisive monetary policy messages supported by an increase in reserves might have some positive effects on expectations held by corporations and households with respect to the future course of the economy and prices.

One and a half years have passed since the Bank introduced this new policy regime. Based on experiences and related data so far, we analyze the effects of “quantitative monetary easing” measures at zero interest rates and try to make a tentative evaluation. The rest of the paper proceeds as follows. We begin in Section 2 by surveying recent developments in monetary policy and the observed reactions of financial indicators. In Section 3 we survey the transmission mechanism of monetary policy at zero interest rates from a theoretical viewpoint. In Section 4, taking into account the regime change in monetary policy and the possible non-linearity of money demand at low (or near zero) interest rates, we use a Bayesian VAR, a VAR with time-varying coefficients, to extract the effects of the increase in monetary base. In Section 5, we investigate whether a satiation level of money demand exists at zero interest rates by estimating a money demand function. In Section 6, we then estimate models that include both aggregate demand and aggregate supply functions and examine whether monetary base enters these equations significantly. In Section 7, we discuss reasons why the expansion of monetary base at zero interest rates has a limited and uncertain effect on the economy. Section 8 presents concluding remarks.

2. Recent Developments in Monetary Policy in Japan and the Reaction of Financial Indicators

The collapse of asset prices in the early 1990s was the beginning of a long economic slump in Japan, which is characterized as several deep cyclical downturns with some modest short-lived economic recovery. There is a consensus among policy-makers and economists that one of the basic structural problems Japan's economy has faced is the non-performing loan (henceforth NPL) problem of the banking sector. The impaired balance sheet of the banking sector has prevented the transmission mechanism of monetary policy from working smoothly, thereby dampening the financial and economic responses to monetary policy easing.

As early as 1995, the Bank of Japan had little room for further reducing interest rates. The Bank maintained the uncollateralized overnight call rate as low as around 0.5 percent despite the fact that Japan's economy recovered at more than 3 percent growth rate of GDP from 1995 to 1996. In autumn 1997, Japan's economy turned to deteriorate, which was largely influenced by financial system disturbance reflecting the failure of large financial institutions. The Bank successively lowered the overnight call rate to 0.02 percent in February 1999. The period between 1999 and 2000 is often called the "zero-interest rate" period. In August 2000, the Bank lifted its "zero-interest rate" policy and raised the overnight call rate to 0.25 percent, since the economy was showing clear signs of recovery and its continuation. However, in late 2000, the economy turned to deteriorate again reflecting the adjustment of global IT and related exports, and concern over deflation intensified. The Bank lowered the policy interest rate one last time to 0.15 percent and then adopted quantitative monetary easing in March 2001. In sum, while the non-performing loan problem of the banking sector has been a serious factor weakening the effects of accommodative monetary policy, the zero bound of interest rates has become increasingly an even more intractable issue from the viewpoint of monetary policy formulation.

That was the background leading to the Bank of Japan's decision to finally discard the orthodox operating framework and adopt a new framework under which it set the outstanding balance of current accounts at the Bank, instead of the uncollateralized overnight call rate, as the main operating target. When the Bank adopted this new regime, it raised the target level of the current account balance to around 5 trillion yen (March 2001), about 1 trillion yen larger than that immediately prevailing before the change (Chart 1). After that, it raised the target level to around 6 trillion yen (August 2001), more than 6 trillion yen (September), and 10 to 15 trillion yen (December). Also, on February 28, 2002, to secure financial market stability towards the fiscal year-end, the Bank decided to provide more liquidity to meet a surge in demand irrespective of the target of current account balances, around 10 to 15 trillion yen. Just before the year-end, the Bank provided a maximum 27 trillion yen, and since the end of the year factor faded, the current account balance has been running around 15 trillion yen.

Meanwhile, in order to smoothly provide liquidity, the Bank increased its outright purchase of long-term government bonds from 400 billion yen to 600 billion yen per month in August 2001, and thereafter to 800 billion yen in December, and further to 1 trillion yen in February 2002.[1]

After adopting quantitative easing, the growth rate of monetary base started to markedly rise from the second half of 2001, reaching some 30 percent year on year in March-April 2002, the highest rise since the first oil shock in the 1970s (Chart 2). This has reflected the Bank's ample provision of reserves and increase in demand for cash caused by the decline in the opportunity cost of holding money. As a result, the ratio of monetary base to nominal GDP has increased to 17 percent, the highest figure after the Second World War period.

While monetary base has posted double-digit percent growth year on year, what has been the reaction of financial markets since quantitative easing was adopted?[2]

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[1] In October 2002, the Bank of Japan decided to aim at the outstanding balance of current accounts held at the Bank at around 15 to 20 trillion yen, and to increase its outright purchase of long-term government bonds from 1 trillion yen to 1.2 trillion yen per month.

[2] See Shirakawa (2002) for details.

First of all, amid the unprecedented abundant supply of liquidity, not surprisingly the uncollateralized overnight call rate was further lowered to 0.001 or 0.002 percent, almost literally zero (Chart 3). Another element of the new policy regime is a commitment to continue it until underlying CPI inflation turns positive. Currently in Japan, given economic weakness and persistent downward pressure on prices, most market participants do not see CPI inflation turning positive anytime soon. Reflecting such an expectation, the decisive easing stance of the Bank of Japan exerted some downward effect on medium-term forward interest rates (Chart 4).

Second, as the partial removal of blanket deposit insurance (for time and savings deposits, etc.) approached, shifts from time and savings deposits to liquid deposits, and deposit shifts among financial institutions were widely seen until the end of fiscal 2001 (Chart 5). However, the substantial provision of reserves by the Bank succeeded in dispelling the liquidity concerns of financial institutions at the end of the fiscal year. Chart 6 shows the premium on the implied forward euro-yen rate stepping over the end of the fiscal year, providing evidence of this situation.

Third, a current account balance increase does not seem to have a strong effect on the corporate financing environment in capital markets such as corporate bond and CP markets. Facing the weakening role of banks as financial intermediaries, enhancing the function of capital markets could be an important route of monetary easing. In this regard, the corporate financing environment has partly improved. The differential (credit spread) between interest rates on corporate bonds and CP and yields on risk-free government bonds declined marginally after March 2001. It should be noted, however, that firms who reap the benefits of monetary easing effects are limited to those with high credit ratings. The effects have not fully permeated to firms with low credit ratings and those incapable of accessing capital markets. Credit spreads on low-grade corporate bonds have been rising since October 2001, because investors have become more conscious of credit risk.

Fourth, the prices of other financial assets do not seem to respond to quantitative easing. From March 2001, stock prices temporarily rose until around May because of the anticipated favorable impact of structural reform, but turned to decline thereafter due to a deterioration in the economic outlook (Chart 8). After a short recovery from March 2002, stock prices gradually declined again reflecting mainly the plunge in US stock prices. As such, while stock prices fluctuate reflecting various factors, the most important one seems to be prospects for economic fundamentals, not an increase in monetary base. As for foreign exchange rates, the yen rate against the dollar mostly moved in the lower 120s but temporarily rose to 116 in September 2001 (Chart 9). The yen depreciated rapidly from November 2001 until February

2002. This seems to be attributable not to monetary easing but rather a change in the economic outlook, as typically reflected in Japan's stock prices; while expectations for recovery of the US economy strengthened, uncertainty over prospects for Japan's economy intensified, including financial system stability. Thereafter, reflecting the plunge in US stock prices, the yen appreciated again to the 115 level in July 2002, and has recently been changed little around 120. So far, it is not clear that the exchange rate and monetary base appear to move in a same way.

Finally, as for credit and broad money indicators, bank lending has kept decreasing, while the growth rate of M2+CDs has been stable at around 3 percent (Chart 2). The decline in bank lending and moderate growth in deposits should result in an increase in some other investments. So far, banks have increased investment in government bonds and Bank of Japan current accounts, both of which are free of credit risks.

In sum, at a first sight of monetary and financial indicators, there is no clear evidence that quantitative easing has provided discernible effects with some exceptions at zero short-term interest rates. However, in order to judge carefully the entire effects of quantitative easing, we need to evaluate them quantitatively by conducting empirical analyses based on economic theory.

3. Monetary Policy Transmission at Zero Interest Rates

3.1. Monetary Base Channel

The interest rate channel is the primary mechanism in conventional Keynesian macroeconomic models, which works through the change in the short-term interest rate. If only this channel worked, the economy would be under a liquidity trap when the short-term interest rate is zero.[3] However, monetarists criticize such a Keynesian view saying that conventional macroeconomic models significantly oversimplify the structure of the economy. In the traditional monetarist account, for a full liquidity trap to be effective, the composite asset—money plus bills—must be a perfect substitute for all other assets (Meltzer (1999)). In practice, however, money is an imperfect substitute for a wide range of financial and real assets,

[3] A 'liquidity trap' was suggested by Keynes in the General Theory and revived recently by Krugman (1998,1999).

including long-term bonds, corporate bonds, equities, foreign financial assets, physical capital, and durable goods.[4] A change in monetary policy induces a re-balancing of portfolios in general, affecting nominal demand both through wealth and substitution effects on real assets, and through adjustments in a wide range of financial yields relevant to expenditure decisions.

In a theoretical viewpoint, even at zero interest rates the change in the monetary base is expected to cause this re-balancing effect through the following channels.

The first channel is a relative asset-supply effect. An open market operation by a central bank causes an opposite change in the stocks of monetary base and securities held by banks, firms, or households. Since monetary base is not a perfect substitute for various other assets, changes in the outstanding balance of monetary base due to monetary policy may lead to changes in the relative prices of assets. This relative asset-supply effect can be realized by changes in risk premium of asset prices. For example, Meltzer (2000) and McCallum (2000) argue that monetary authorities can use the monetary base to engineer exchange rate depreciation even when short-term nominal interest rates are zero. Implicitly, they view the risk premium in the uncovered interest parity relationship as subject to monetary policy manipulation in the short run.[5]

Risk premium can also be reduced by the second channel which would work through the reduction of transaction costs by providing ample money.[6] The frictions which money helps to overcome in financial markets are related to its role in providing liquidity services. When economic agents anticipate a liquidity shortage regarding their future revenues, they will boost

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[4] Some representative quotes of monetarists' views :

Meltzer (1999b): "Monetary policy works by changing relative prices. There are many, many such prices. Some economists erroneously believe...monetary policy works only by changing a single short-term interest rate."

Friedman and Schwartz (1982, pages 57, 58): "Keynesians regard a change in the quantity of money as affecting in the first instance 'the' interest rate, interpreted as a market rate on a fairly narrow class of financial liabilities... We insist that a far wider range of marketable assets and interest rates must be taken into account… [We] interpret the transmission mechanism in terms of relative price adjustment over a broad area rather than in terms of narrowly defined interest rates."

[5] However, empirical studies seem to have concluded in general that changes in the relative supply of dollar and foreign currency bonds have little or no lasting impact on exchange rates. In addition, although many useful studies have attempted to measure the degree of substitutability between dollar and foreign currency bonds, there are still no generally accepted estimates of these crucial parameters. These findings suggest that portfolio re-balancing effects on the exchange rate are probably negligible for small- to medium-sized changes in the relative quantities of dollar and foreign currency bonds. Of course, they do not preclude the possibility that the Bank of Japan could cause a depreciation of the yen even at the zero bound. However, very large purchases of foreign currency bonds would be required to achieve a significant result.

[6] See, for example, King (1999,2002).

demand for liquid assets to avoid borrowing due to cash flow constraints. Such asset demand in preparation for a liquidity shortage leads to the higher evaluation of liquid assets. That is, liquidity demand might substantially raise the rates of illiquid assets relative to those of liquid assets due to a liquidity premium.[7] In such circumstances, the increase in money will reduce the probability of liquidity shortage, and consequently affect the liquidity premium and relative asset returns. The relief from concern over the liquidity of financial institutions, mentioned at the second point of the reaction of financial market (p.4), can be understood as such an example (Chart 6). From a different perspective, it might be expected that investors take risks more because of a decrease in liquidity risk premium. Financial institutions might be a candidate of such investors, and if they changed their attitude for lending, it would have a positive impact on aggregate demand. In this way, recognizing the role of money in reducing financial frictions may provide a more significant role for money in the transmission mechanism.

The expectation effect is another channel. A central bank can lower longer term interest rates even when nominal short-term interest rates are zero. Because longer term rates are formed as averages of expected short-term rates plus some risk premium over their maturity, committing to maintaining the zero interest rate policy longer will lower expected future short-term interest rates. As the strength of this channel relies on the expectation of firms and households with respect to future monetary operations of the central bank, current changes in the market operation, realized as an increase in the monetary base, may be expected to enhance the credibility of the central bank.[8] If this contributed to diminishing uncertainty over future short-term interest rates, term premium would be reduced and hence longer term rates would be lowered further. The above-mentioned decline in medium-term forward rates in Japan can be regarded as a typical example (Chart 4). It should be noted, however, that this expectation effect can also be classified as a part of interest rate channels with longer term maturities.

As a variety of logic argues a variety of channels, it is difficult to crystallize all into a simple channel. Hereafter, this paper tentatively calls them the "monetary base channel." As mentioned above, the monetary base channel depends on various changes in yields (or relative prices), rather than money *per se*.[9] Meltzer (1995,1999) argues that a measure of monetary

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[7] Saito and Shiratsuka (2001) points out that Japan's financial institutions severely faced the liquidity constraints during the financial crises that occurred in 1997 and 1998, and that the serious liquidity constraint prevailing in the banking sector resulted in depressed loan activities, limited arbitraging, and poor dealing among financial markets.

[8] See, for example, Meyer (2001).

[9] There is another view that focuses on money *per se*; the real balance effect (Pigou (1943)). However,

conditions based on real money stock can be regarded as a better summary of the various changes in yields than a measure based on a specific real interest rate. One reason he offers for this is that money demand might, like aggregate demand, be a function of many interest rates, as in Friedman (1956).

3.2. Review of Literature on Empirical Analyses

When the monetary base channel works and real money stock serves as a better summary of the various changes in yields relevant for economic activities, monetary base enters the aggregate demand equation for a given short-term interest rate. That is, money could play a role in structural equations for aggregate demand, or in VARs, as a proxy for channels which are not summarized by the real interest rate on short-term securities.

Koenig (1990) and Meltzer (1999) show that real money growth is a significant determinant of consumption growth in the US, controlling for the short-term real interest rate. Nelson (2000) also shows that the same property of base money holds for total output (relative to trend or potential) in both the US and the UK. However, do these analyses indicate that monetary base channel works at zero interest rates? While econometric models that are estimated using data of normal periods when the economy operates safely away from the zero bound can provide useful estimates of monetary transmission through the interest rate channel, they are unlikely to capture the effects of monetary base channel that may remain operative when nominal interest rates are constrained at zero with considerable precision. Taking this point into account, we cannot necessarily regard the empirical analyses of Koenig (1990), Meltzer (1999a) and Nelson (2000) as evidence of the existence of the monetary base channel at zero interest rates, since their analyses do not include any samples from the zero interest rate period.

As for Japan's case, Baig (2002), using the VAR based on the data from 1980 to 2001, shows that expansion of monetary base has positive effects on both price and output even with the interest rate included in the VAR as a separate variable. Then, Baig (2002) argues that Japan's data support the existence of the monetary base channel even at zero interest rates. However, we have to examine whether his analysis really indicates the effectiveness of the monetary base channel at zero interest rates in Japan. Although Baig (2002) uses Japan's data

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monetary base, namely 'outside' money, accounts for only a very small fraction of financial wealth in developed countries. So the quantitative impact of the real balance effect is inevitably small.

including the sample period of zero interest rates, his analysis is based on a VAR model which does not allow for time-varying parameters. In other words, his empirical results do not reflect the effect of the monetary base channel at zero interest rates, but the average effect of that channel during the whole sample period. This is a problem which arises from using a long sample which includes different policy regimes. Therefore, we cannot necessarily recognize that the analysis of Baig (2002) suggests the effectiveness of monetary base channel at zero interest rates in Japan.

Indeed, the results of Baig (2002) do not seem to be consistent with Japan's recent economy. Although the growth rate of monetary base has continued very high for several years, deflation persists in the economy, albeit at low rates (Chart 2). If his results were right, deflation would have stopped. Needless to say, money affects the economy with long and variable lags. We may have to wait just a bit longer. However, the usual range for the lag in the effects of monetary policy on the economy lies somewhere between half a year and approximately two years or so. Consequently, we seem to be witnessing something very unusual in the relationship between money and the economy.

4. Empirical Analyses Based on a Time-Varying VAR

In the previous section, we pointed out the problem regarding the empirical method of investigating the effect of the monetary base channel at zero interest rates. We should not extract the average effect of the monetary base channel during a long sample period, but that reflecting the sample period of zero interest rates only. Bayesian VAR, a VAR with time-varying coefficients, is one way to solve this problem.[10] Using a time-varying VAR, we allow for possible changes in the interest rate elasticity of money demand and changes in the transmission mechanism at (near) zero interest rates. Since the Bank of Japan faced the zero interest rate bound, its policy reaction function has clearly changed. The regime change in monetary policy, from interest rate targeting to quantitative easing, will bring shifts in the responsiveness of economic activity to the increase in monetary base. Time-varying VAR can capture these changes in economic structure and leads to impulse response functions that vary over time.

[10] See Doan, Litterman, and Sims (1984) for details of Bayesian VAR.

4.1. VAR

Before estimating a time-varying VAR, we begin by estimating VAR as a benchmark, using Japan's quarterly data over the sample period 1980:1-2002:1. The sample period is chosen to be the same as that in Baig (2002). The specific VAR that we consider contains four variables: inflation rate, output gap, monetary base (growth rate), and the overnight call rate.[11,12] Clearly, this VAR provides a very simple or simplistic description of the economy, but it contains at least the minimum set of variables that are crucial for any discussion of monetary policy.[13] We include four lags in the VAR according to AIC. The VAR is identified by using the Choleski decomposition, with the order being inflation, output gap, interest rate and monetary base. The choice of ordering is made, according to Baig (2002), on the basis of the speed with which the variables respond to shocks, i.e. inflation is assumed to respond last, and monetary base to be the most responsive.

Chart 10 displays impulse response functions based on the estimated VAR. The basic results are the same as those of Baig. That is, both inflation and output gap respond positively to innovations in monetary base. Although these responses are not statistically significant, using a longer sample period, 1971:2-2002:1, results in significant response (Chart 11).[14] As noted earlier, however, this result does not reflect the effect of the monetary base channel at zero interest rates, but the average effect of the channel during the whole sample period. It can be guessed that the experiences of the 1970s contributed to this result. Therefore, it is not necessarily appropriate to regard the results based on VAR as evidence of the existence of the monetary base channel at zero interest rates.

4.2. Time-Varying VAR

Now, we estimate a time-varying VAR to properly analyze the effects of the monetary base channel at zero interest rates. Write the j th equation in a VAR as

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[11] See Data Appendix for detailed description of the data.

[12] To check the robustness of our results, we have re-estimated VAR by replacing output gap with output growth. While we report only the results obtained from the VAR with output gap, the VAR with output growth yields very similar results.

[13] To limit the extent of a "price puzzle" (see Sims (1992), Chari, Christiano, and Eichenbaum (1995), and Bernanke and Mihov (1998)), we re-estimate VAR including commodity price inflation (or wholesale price index), but main results do not change.

[14] The original and available data set runs from 1970:1 to 2002:1. Because of data transformation (first-differences and lags), the analysis is performed on the 1971:2-2002:1 period.

$$x_{t,j} = X_{t-1}{}' b_{t,j} + u_{t,j} \ , \tag{1}$$

where $x_{t,j}$ is j th endogenous variable, X_{t-1} is a vector of lagged variables, and $u_{t,j}$ is a error term. $b_{t,j}$ is a vector of time-dependent parameters and is assumed to follow a random walk process. $b_{t,j}$ is updated according to a Kalman filter algorithm, based on a prior distribution on the initial value of a parameter vector $b_{0,j}$.[15] Since $b_{t,j}$ is time-dependent, the impulse response functions vary over time.

We focus on the impulse response functions at 1985:2 and those at 2002:1. The former functions are based on the parameter $b_{1985:2}$, while the latter based on the parameter $b_{2002:1}$. These parameters are estimated by a Kalman filter over sample periods 1971:2-1985:2 and 1985:3-2002:1, respectively. The parameter $b_{1985:2}$ reflects the propagation mechanism of the period just before the Plaza Accord, while $b_{2002:1}$ reflects that after the adoption of quantitative easing. The reason why we compare the impulse response functions at 1985:2 with those at 2002:1 is that 1985:2 is near the midpoint of the whole sample period 1971:2-2002:1. In order to examine whether the propagation mechanism differs between 1985:2 and 2002:1, we calculate the impulse responses to the common innovations whose covariance matrix is estimated over the whole sample 1971:2-2002:1.[16] That is, since the covariance matrix of innovations is kept constant, the difference of the impulse response functions provides a measure of a change in the propagation mechanism in the face of unchanged disturbances.

The result, which is shown in Chart 12, is clearly different from that of VAR. This chart indicates that the increase in monetary base has a positive effect on inflation at 1985:2, but not at 2002:1. This finding implies that beyond the interest rate channel, monetary transmission process took place through the monetary base channel in the 1980s, but such transmission does not work now at zero interest rates. This seems to reflect the recent observation that the high growth rate of monetary base does not lead to an indication of inflation (Chart 2).

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[15] We set the hyperparameters of prior distribution at the values which Doan *et al*. (1984) recommends for a typical economic time series. To check the robustness of our results, we re-estimated time-varying VAR based on the optimized hyperparmters. While we report only the results obtained from the time-varying VAR with the hyperparamters which Doan *et al*. (1984) recommends, the time-varying VAR with the optimized hyperparameters yields very similar results.

[16] The shock is calculated as follows. We first calculate the residuals from the coefficients at each period, then the covariance matrix and make the orthogonal shock using Choleski decomposition. The ordering is chosen to be the same as that of VAR: inflation, output gap, interest rate, and monetary base.

The lag-length is also chosen to be the same as that of VAR, that is, four lags are included in time-varying VAR.

4.3. Implicit Assumption of the Monetary Base Channel

Why does the underlying mechanism of the monetary base channel not work well as theoretically assumed? Here, it should be noted that the monetary base channel at zero interest rates is based on the implicit assumption that money demand is satiated at a finite level. That is, when interest rates are zero, households and firms become satiated with money balances, and any increase in the monetary base beyond that level leads to changes in their portfolios with consequent changes in relative yields on different financial and real assets, and direct and indirect effects on spending.[17] In contrast with such a view, there is another view. When interest rates are zero, households and firms have an infinitely elastic demand for money balances. An increase in the monetary base is absorbed passively in higher balances, and there are no implications for broader measures of money or demand and output. Monetary policy is impotent; there is a liquidity trap.

Which view is consistent with the result of our analysis? As background to the result of time-varying VAR, we can set two hypotheses:

Hypothesis I: As the interest rate tends to zero, demand for money balances tends to infinity. Therefore, monetary policy has no effect on economic activity at zero interest rates, because any additional money created is simply absorbed passively in money holdings.

Hypothesis II: Money demand exhibits satiation such that the demand is finite at zero interest rates. Therefore, the monetary base channel works even at zero interest rates, but its effect is very small or negligible.

In order to test which hypothesis is accepted, we must estimate the money demand function and examine whether there is a satiation level of money demand at zero interest rates.[18] The next section deals with this issue.

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[17] We must note that if there are only two financial assets, money and bonds, in the economy, the existence of a finite satiation level of real balances does not mean the existence of a monetary base channel at zero interest rates. Money demand is infinitely elastic at a satiation level in the sense that no further interest-rate declines are needed to make people willing to hold larger real balances, even if the elasticity of money demand is bounded at all interest rates greater than zero. For an example of a simple model in which the monetary base channel is ineffective at a zero interest rate, and in which there is satiation in real balances at a finite level, see the discussion of "real balance effects" in Woodford (2002).

[18] Baig (2002) uses monetary base (expressed as a ratio of potential output) and the level of interest rate in VAR with a fixed parameter, which implicitly assumes that there is a satiation level of money demand at zero interest rates. Instead of the level of interest rates, if a logarithmic specification for interest rates is used as a variable of VAR, it implicitly assumes that money demand tends to infinity as the interest rate tends to zero, that is, there is not a satiation level of money demand at zero interest rates.

5. Satiation Level of Money Demand

5.1. General Money Demand Function

As in Friedman (1956), the demand for real balances depends not on a single interest rate but on many different interest rates, or, more generally, on the prices of assets relative to the prices of new production of the same assets. These relative prices settle down as the economy adjusts to an equilibrium at which all assets sell at replacement cost. In a full, general equilibrium, prices of bonds and real capital, of domestic and foreign assets, of new and used houses and automobiles, and many other relative prices, can be usefully summarized by a single interest rate. In transition, however, this does not hold true, and the demand for real balances differ from long-run desired real balances. Based on such a logic, Meltzer (1999) argues that the difference between actual and long-run desired money balances is a measure of the excess supply of money, the amount by which prices and other nominal variables must change to restore equilibrium in markets for assets and output.[19]

Here, we assume that long-run desired real balances can be modeled as follows:

$$\frac{M_t}{P_t} = e^{g} Y_t^{a} \left(\frac{i_t}{1+i_t} + d \right)^{-b}, \quad a > 0,\ b > 0,\ d \geq 0\ , \tag{2}$$

where M_t, P_t, Y_t, and i_t are monetary base, price level, real income, and call rate, respectively. a, b, g and d are parameters. In equation (2), it is assumed that the relative prices of various assets can be usefully summarized by the call rate i_t in the long run.

Equation (2) is consistent with a transactions-time approach and inventory-theoretic approach to money demand. The inventory-theoretic approach says that managing an inventory always requires time, and a larger real balance of money can reduce transaction time. A variation of the transactions-time approach is that consumption requires shopping time, which can be decreased by holding a larger real balance. In order for the transactions-time approach to be consistent with satiation, it must be such that at some positive real balance amounts, further increases in that ratio would not decrease transactions-time.[20] It should also be noted

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However, a constraint about whether there is a satiation level of money demand at zero interest rates should not be imposed on the money demand function *a priori*, but be tested statistically.

[19] An alternative view is that the economy adjusts to reduce this gap by spending to reduce the real balance of money, when real balances are larger than desired, or to increase the gap by reducing spending when real balances are less than desired. This so-called "real balance effect" is generally considered small, since real balances are a small part of real wealth in developed countries.

[20] See Bakhshi *et al*. (2001) and Wolman (1997).

that equation (2) nests two familiar money demand functions as special cases: the log-log function and semi-log function. Consider the case when call rate i_t is low enough for the approximation $i_t/(1+i_t) = i_t$ to be reasonable. Taking logs of equation (2) when d=0, we get log-log function:

$$m_t - p_t = a\, y_t - b \log(i_t) + g \quad , \tag{3}$$

where all lowercase letters, excluding interest rate i_t, refer to logarithms of the variables in uppercase letters. The elasticity of money demand with respect to interest rates is a full elasticity, which shows the percentage change in money demand in response to a one percent change in interest rates. On the other hand, taking logs of equation (2) when d>0 and $d \gg i_t$, we get semi-log function:[21]

$$\begin{aligned} m_t - p_t &= a\, y_t - b \log(i_t + d) + g \qquad (4) \\ &= a\, y - b \log\left(1 + \frac{i_t}{d}\right) - b \log d + g. \\ &\approx a\, y - \frac{b}{d} i_t + (g - b \log d) \qquad \text{(Note that } \log(1+x) \approx x \text{ for small } x) \end{aligned}$$

The response of money demand to interest rate changes is a semi-elasticity, which indicates the percentage change in cash holdings as a result of a one-percentage-point change in interest rates.

In equation (2), the satiation level of money balances (expressed as *quasi*-Cambridge k) at zero nominal interest rates is

$$k = \left. \frac{M}{PY^a} \right|_{i=0} = d^{-b} e^{g} \quad , \tag{5}$$

which is finite if d>0.[22] In contrast, if d=0, this ratio k is infinite, which implies that there is no satiation level of money demand. Regarding log-log and semi-log money demand functions, the former does not have a satiation, whereas the latter does. The figure below illustrates the money demand curve and the location of the satiation level.

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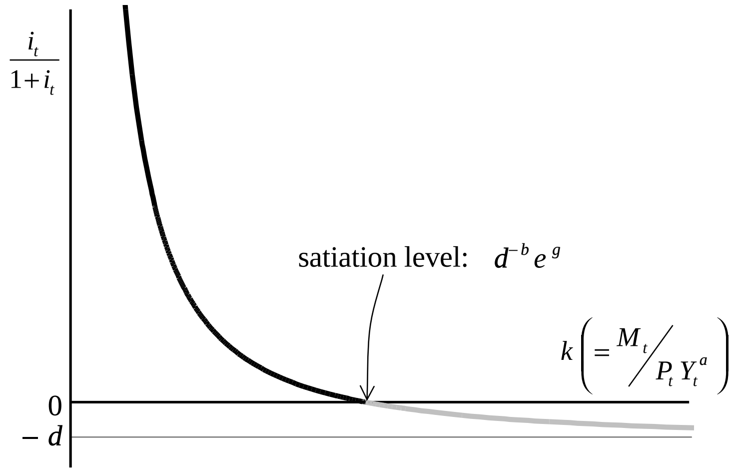
[21] When condition $d \gg i_t$ is not satisfied, this approximation does not hold true even if d>0.

[22] Here, we call $M/(PY^a)$ "*quasi*-Cambridge k", because a is not necessarily unity, while a is set at unity for original Cambridge k.



Whether d is zero or strictly positive gives a rather different policy implication. In the case of d = 0, monetary policy would have no effect on real demand and output, because any additional money created would simply be absorbed passively in money holdings. In contrast, in the case of d> 0, the monetary base channel works even at zero interest rates, because the creation of money beyond the satiation level would be translated into demand for other assets and, ultimately, via effects on relative yields, into nominal spending.

5.2. Estimation Result

Now, we estimate a money demand function and examine whether there is a satiation level of money demand.

Before estimating equation (2) and testing the hypothesis that there is no satiation level (d =0) in equation (2), we first attempt to examine whether either of the functions, the log-log function (3) or semi-log function (4), is appropriate for the long-run desired real balance. If equation (3) or (4) is appropriate for the long-run demand function, we will find a cointegrating relationship among real money (m_t-p_t), income (y_t) and interest rate (i_t or log(i_t)). Using Johansen's (1988) maximum likelihood estimation procedure, we conduct a cointegrating test over the sample period 1978:1-2002:1. The sample period is chosen to avoid the high inflation period of the first round increases in oil prices, since the behavior of holding cash balances in the private sector may have changed after transition to a moderate or low inflation period. In addition, the policy stance of the Bank of Japan might also have changed after the first oil shock. Indeed, in 1978, the Bank began announcing quarterly forecasts of money supply.

Chart 13 shows the results of the maximum eigenvalue and trace test statistics of the Johansen test for log-log and semi-log functions. Both tests suggest that, for both specifications, there is no cointegrating vector among real money (m_t-p_t), income (y_t) and interest rate (i_t or log(i_t)). This implies that neither the semi-log nor log-log function is appropriate for the long-run money demand function. A more general money demand function is desirable; therefore estimating equation (2) is the next step.

For estimation purposes, we rearrange equation (2) as follows:[23]

$$\frac{\frac{M_t}{P_t} - e^{g} Y_t^{a} \left(\frac{i_t}{1+i_t} + d \right)^{-b}}{e^{g} Y_t^{a} \left(\frac{i_t}{1+i_t} + d \right)^{-b}} = \frac{k_t}{e^{g} (ii_t + d)^{-b}} - 1 = e_t \ , \tag{6}$$

$$\text{where } \ k_t = \frac{M_t}{P_t Y_t^{a}}, \ \ ii_t = \frac{i_t}{1+i_t} \ .$$

e_t is the percent deviation of actual money balances from long-run desired money balances. We can assume that the mean of e_t is zero and that two composite variables, k_t and ii_t, follow a stationary process. Regarding e_t as an error term, we estimate equation (6) with instrumental variables using the generalized method of moments (GMM). The reason why we use GMM is that e_t can be considered highly auto-correlated and that the regressors, k_t and ii_t, in equation (6), are themselves endogenous. Due to difficulty in calculation convergence, the estimation of parameter a is carried out by a grid search method. The search is carried out over the range $0.5 \le a \le 1.5$ at intervals of 0.001.

Estimation results, shown in Chart 14, are clearly consistent with the existence of a satiation level of money demand. Parameter d is significantly positive, since the null hypothesis $d = 0$ can be rejected at the 5% significance level (p-value = 0.011). This result of $d > 0$ is consistent with the cointegration test which suggests log-log function (4) is inappropriate for the long-run money demand function. The result also implies that equation (2) can be approximated by semi-log function (3) when $d \gg i_t$. When condition $d \gg i_t$ is not satisfied, however, equation (2) differs from semi-log function (3). Chart 15 displays a plot of k_t versus ii_t. The solid line in this chart shows fitted values when parameters are estimated without any constraint, and the dashed line shows fitted values when non-satiation is imposed ($d = 0$).

[23] When $d > 0$, we cannot use Johansen's (1988) maximum likelihood estimation procedure to estimate the parameter d in equation (2), since taking logs of equation (2) does not lead to a linear system.

In order to confirm that equation (2) is appropriate for the long-run money demand function, we also conduct a unit-root test for the error term e_t in equation (6). When equation (2) is appropriate for the long-run money demand function, we will find that e_t naturally follows a stationary process. Chart 16 shows the results of ADF test and Phillips-Perron test. Both tests suggest the null hypothesis that e_t follows a non-stationary process can be statistically rejected.

Although we may need more data of zero-interest rate period to estimate the money demand function with much precision, we can tentatively conclude that equation (2) with strictly positive d is appropriate for the long-run desired money function, and reject "Hypothesis I" in Section 4.3. There is a satiation level of money demand at zero interest rates, which leaves room for the monetary base channel to work even at zero interest rates. But, to what degree does the monetary base channel work? Taking the results of time-varying VAR into account, "Hypothesis II" in Section 4.3. seems to be supported; the effect of the monetary base channel at zero interest rates is very small (or negligible), if any. In order to support this view, in the next section, we estimate the model that includes both aggregate demand and aggregate supply equations and examine whether monetary base enters these equations significantly.

6. Effectiveness of the Monetary Base Channel

Our model is small scale but a standard macroeconomic model which comprises four basic equations: aggregate demand function (IS curve), aggregate supply function, money demand function (LM curve), and monetary policy rule. The aggregate demand function relates total demand to either money or interest rates and to expected inflation. The aggregate supply function relates the inflation rate to either the output gap or real money gap and to inflation expectations. The money demand function relates real cash balances to total expenditure and the interest rate. The monetary policy rule relates the interest rate to the difference between inflation and the central bank's inflation target. The model determines the values of output, inflation, the interest rate, and money growth. Much recent research on monetary policy is based on variants of this four-equation system.

Using the four-equation system, we first estimate the model, as a benchmark, where money plays no role in determining output and inflation. Such a model is often called "passive money paradigm." Then, we estimate the model where money plays an explicit role in determining output and inflation. This model is often called "active money paradigm."[24]

6.1. Passive Money Paradigm: Benchmark Model

Our benchmark model based on passive money paradigm is described as follows:

(AD) $$y_t - y_t^n = f\,(y_{t-1} - y_{t-1}^n) - s\,\left(i_{t-1} - E_{t-1}[\Delta\, p_t] - r_{t-1}^n\right) + h_t^{AD} \tag{7}$$

(AS) $$\Delta\, p_t = q\,\Delta\, p_{t-1} + (1-q)\,\Delta\, p_{t-2} + \,l\,(y_{t-1} - y_{t-1}^n) + h_t^{AS} \tag{8}$$

(LM) $$\Delta\, rm_t - \Delta\, rm_t^n = t\,(\Delta\, rm_{t-1} - \Delta\, rm_{t-1}^n) - y\,\,(e_{t-1}) + h_t^{LM}\ , \tag{9}$$

$$\text{where}\ \ e_t = \frac{\dfrac{M_t}{P_t} - e^{g} Y_t^{a}\left(\dfrac{i_t}{1+i_t} + d\right)^{-b}}{e^{g} Y_t^{a}\left(\dfrac{i_t}{1+i_t} + d\right)^{-b}} \approx rm_t - a\,\,y_t + b\,\log\left(\frac{i_t}{1+i_t} + d\right) - g, \quad rm_t = m_t - p_t\,,$$

$$rm_t^n = a\,\,y_t^n - b\,\log\left(\frac{i_t^n}{1+i_t^n} + d\right) + g$$

(MP) $$i_t = \frac{i_t^* + \sqrt{(i_t^*)^2 + w}}{2} + h_t^{MP}\ , \tag{10}$$

$$\text{where}\ \ i_t^* = i_t^n + m\left[\frac{(\Delta\, p_t - p_t^*) + (\Delta\, p_{t-1} - p_{t-1}^*)}{2}\right] + n\,(y_t - y_t^n)\ ,\ \ i_t^n = p_t^* + r_t^n\ ,\ \ r_t^n = \Delta y_t^n + \text{constant}$$

[Symbols][25]

y_t, output; y_t^n, potential output; $y_t - y_t^n$, output gap; Δy_t^n, potential growth rate; p_t, price level; Δp_t, inflation rate; m_t, nominal money balance (monetary base); rm_t, real money balance; Δrm_t, real money growth; rm_t^n, long-run desired real money balance; e_t, percent deviation of actual money balances from long-run desired money balances; i_t, call rate; i_t^*, desired call rate prescribed by simple policy rule; i_t^n, equilibrium nominal interest rate; r_t^n, equilibrium real interest rate; p_t^*, central bank's inflation target; $i_t - E_t[\Delta\, p_{t+1}]$, real interest rate; h_t^{AD}, demand shock; h_t^{AS}, supply shock; h_t^{LM}, monetary shock; h_t^{MP}, interest rate shock; f, s, q, l, t, y, w, m, all the parameters are expected to be positive ($1 > f \geq 0$, $1 \geq t \geq 0$, $w > 0$, $m > 1$).

The aggregate demand function (7) and aggregate supply function (8) are conventional IS

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[24] See Laidler (1999) and Engert and Selody (1998).

[25] See Data Appendix for detailed description of the data.

and Phillips curves.[26,27] The money demand function (9) is a standard error correction model. Taking the zero interest rate bound into account, we explicitly incorporate the non-negativity constraint on interest rates into the policy rule (10). Call rate i_t is equal to desired rate i_t^* prescribed by the simple policy rule when i_t^* is above zero, while i_t is set at zero when i_t^* is below zero.[28] This defines two linear relationships between i_t and i_t^* (if $i_t^*>0$, $i_t = i_t^*$, otherwise, $i_t = 0$). We assume that the relationship between the actual call rate and desired rate is slightly smoother than suggested by the linear formulas. We assume that this is approximated by a hyperbola with the two lines as asymptotes. The parameter w in equation (10) measures the extent that the hyperbola is distant from the two lines. As clear from the IS curve (equation (7)), we here assume that monetary policy operates with a one period lag.

An important feature of the above model based on a passive money paradigm is that real money stock (or its growth rate) appears neither in the IS nor Phillips curve. This model therefore limits the influence of monetary policy on output and inflation to its effect on the real interest rate.[29] Money itself does not play any active role in the transmission mechanism of monetary policy.

We estimate the above model using GMM.[30] Since single-equation and system estimates

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[26] In recent research on monetary policy, the IS curve and Phillips curve range from purely backward-looking specifications (e.g. in Rudebusch and Svensson (1999)) to forward-looking, theory-based optimizing specifications. Here, we focus on the backward-looking model.

[27] Since we use the GDP deflator as inflation rate Δp_t, we do not need to add the exchange rate (or import prices) to the Phillips curve,.

[28] Consider the case when the central bank's loss function is the unconditional expectation of the discounted sum of quadratic deviations of output from potential and quadratic deviations of inflation from a target of zero. Given this assumption and the model comprised of equations (7)-(9), the linear-quadratic nature of the problem implies that a simple representation of the optimal policy takes the following form similar to the Taylor rule, unless the non-negativity constraint on interest rates is binding.

$$i_t^* = i_t^n + m_1(\Delta p_t - p_t^*) + m_2(\Delta p_{t-1} - p_{t-1}^*) + n(y_t - y_t^n)$$

See Gerdesmeier *et al*. (2002) for details. Here, we assume $m_1=m_2$, which leads to equation (10).

[29] Our benchmark model includes only short-term interest rates, not other yields of financial assets, such as exchange rates and equity prices. However, this does not imply our model excludes the effects of monetary policy through a change in those yields. Our benchmark model adequately summarizes this transmission mechanism with a single policy rate under two assumptions: First, monetary policy operates by changing some short-term interest rate; second, all other interest rates and asset prices are linked, directly or indirectly, to the policy rate through stable and predictable arbitrage relationships. However, when this is not the case, that is, when such a transmission cannot be summarized by a single policy rate due to the non-negativity constraint on interest rates, monetary base may play a role in structural equations for aggregate demand or aggregate supply as a proxy for changes in the various yields of financial assets. This issue is treated in the next section.

[30] The parameter of the long-run money demand function (a, b, g, d) is fixed at the value estimated over the full sample (see Chart 14). We also set the parameter w in equation (10) at 0.01 *a priori*.

sometimes differ a great deal, we conduct system estimation in order to appropriately evaluate the relationships between economic variables.[31] Fixing the starting point of regressions at 1978:1, we conduct rolling regressions and examine the stability of estimated parameters. We use the dummy variables, aiming to control for a Y2K-related temporary surge in liquidity demand during the final quarter of 1999. Chart 17 shows estimates of parameters from rolling regressions with the horizontal axis showing the end of the sample period for each regression. All the estimated parameters have the expected sign (positive) and are significant. In addition, all parameters, excluding t and y in the money demand function, are stable. Around the final quarter of 2000, the persistence of money growth (t) begins to increase and the adjustment speed of money stock (y) begins to fall. The background of this result is not clear, but is partly due to the very low opportunity cost of holding money which will reduce private agents' incentives to adjust cash balances quickly.

It should also be noted that the parameter m in equation (10) statistically exceeds 1, that is, the so-called "Taylor principle" is satisfied.[32,33] One piece of conventional wisdom to emerge from the recent study on monetary policy rules is that policy is stabilizing when the central bank raises the nominal interest rate more than one-for-one with the inflation rate. Put differently, under a stabilizing policy, in response to a rise in inflation rate, nominal interest rates should rise sufficiently to increase real interest rates. This implies that monetary policy based on the interest rate channel stabilizes the economy unless the non-negativity constraint on interest rates is binding.

However, once shocks to aggregate demand and/or supply push the economy into a sufficiently deep recession, the zero bound in equation (10) renders the interest rate channel completely ineffective. Because of maintaining expectations of continuing deflation, a zero interest rate policy may not suffice for keeping the real interest rate below its equilibrium level. With a shock large enough to keep the short-term real interest rate above its equilibrium level, aggregate demand is suppressed further sending the economy into a deflationary spiral. This implies that the system comprised of equations (7)-(10) is globally unstable. In the next section, we examine whether we can resolve this global instability, focusing on the monetary base channel that may continue to operate even when the interest rate channel is ineffective.

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[31] See, for example, Leeper and Zha (2001).

[32] The estimated parameters of policy rule (10), $m \approx 1.2$ and $n \approx 0.2$, are slightly smaller than those of the original Taylor rule (m=1.5, n=0.5), but they are roughly the same.

[33] See, for example, Taylor (1999) and Clarida, Gali, and Gertler (1999).

6. 2. Active Money Paradigm

Modifying the benchmark model, we build a model based on an active money paradigm. There are two routes which allow the monetary base channel to work. The first is the possible presence of money terms in the aggregate demand function. The second is the possible presence of money terms in the aggregate supply function. If either route is secured, the central bank can still provide stimulus to the economy even at zero interest rates by increasing monetary base. In the following, we investigate how effective these routes are.

Case 1 Effect of an Increase in Monetary Base on Aggregate Demand

Following Meltzer (1999) and Nelson (2000), we add monetary base as a determinant of aggregate demand to the conventional IS curve (7). The IS curve which we estimate here is as follows:

(AD-AMP) $$y_t - y_t^n = f(y_{t-1} - y_{t-1}^n) - s\left(i_{t-1} - E_{t-1}[\Delta p_t] - r_{t-1}^n\right) + x(\Delta rm_{t-1} - \Delta rm_{t-1}^n) + h_t^{AD} \quad , \qquad (11)$$

where a one period lag of real monetary base growth (less long-run desired growth), $\Delta rm_{t-1} - \Delta rm_{t-1}^n$, is added to the IS curve.

Conducting rolling regressions using GMM, we estimate equations (8), (9), (10) and (11). Estimation results are shown in Chart 18. Overall, adding real monetary base growth to the IS curve does not lead to a change in the estimated parameters. All parameters, excluding parameter x, remain unchanged, and they are almost the same as those estimated under the passive money paradigm. What we should point out here is that the sensitivity of the output gap to a change in monetary base (x) is very unstable. It varies considerably depending on the data set (the end of sample). For example, parameter x is significantly positive in 1997 and around the final quarter of 2000, but not so in 1999. Moreover, estimation with the full sample (1978:1-2002:1) results in a significant but wrong (negative) sign for parameter x. Even when parameter x is significantly positive, the size is rather small, 0.01 at most. This implies a long-run parameter of around 0.1 at most, which is below one-seventh of that found for the US and UK by Nelson (2000).[34]

We now report several robustness checks.

[34] The long-run parameter on real monetary base growth is calculated as $x / (1-f)$. Nelson (2000) finds that the long-run parameter on real monetary base growth ranges from 3.0 to 3.84 for the US and the UK. Since he does not annualize real monetary base growth, we divide his estimates by 4 to compare it with our results fairly.

First, to check the sensitivity of the results to the lag specification, we estimate the following IS curve including the longer and more flexible lag of real monetary base growth:

$$y_t - y_t^n = f(y_{t-1} - y_{t-1}^n) - s\left(i_{t-1} - E_{t-1}[\Delta p_t] - r_{t-1}^n\right) + \sum_{j=1}^{4} x_j\,(\Delta rm_{t-1-j} - \Delta rm_{t-1-j}^n) + h_t^{AD}\ , \qquad (12)$$

where four lags of real monetary base growth are added. Estimation results, shown in Charts 19 and 20, suggest that all parameters, excluding x_i, remain unchanged and that the sum of estimated parameters x_i, Sx_i, is roughly the same as parameter x in equation (11). The p-value of the null hypothesis of Sx_i=0 indicates that the effectiveness of the monetary base channel is highly uncertain. Sx_i is significantly positive in some periods, but not in others. Unlike the results of Chart 18, estimation with the full sample (1978:1-2002:1) results in an expected sign (positive) of Sx_i, but it is not statistically significant. In addition, even the highest value of Sx_i is around 0.02, which is still very small.

Second, to check the robustness of our results, we have re-estimated the model by replacing real monetary base growth with real money stock (less desired money demand), e_t, in the IS curve.[35]

(AD-AMP)
$$y_t - y_t^n = f(y_{t-1} - y_{t-1}^n) - s\left(i_{t-1} - E_{t-1}[\Delta p_t] - r_{t-1}^n\right) + x\,(e_{t-1}) + h_t^{AD} \qquad (13)$$

Although we omit the results, this replacement does not change inferences about the effects of the monetary base channel; namely, it is highly uncertain and very small, if any.

Finally, we estimate the model by adding nominal monetary base growth (less long-run desired growth) to the policy rule. When the monetary base channel works, it is optimal for the central bank to respond to the change in monetary base in order to stabilize the economy.[36] Leaper and Zha (2001) suggest the possibility that estimating the model with different policy rules may result in different estimated parameters of the structural equation. To examine this possibility, we replace equation (10) with the following policy rule and then estimate the system comprising equations (8), (9), (11), and (14).

(MP)
$$i_t = \frac{i_t^* + \sqrt{(i_t^*)^2 + w}}{2} + h_t^{MP}\ , \qquad (14)$$

where $i_t^* = i_t^n + m\left[\frac{(\Delta p_t - p_t^*) + (\Delta p_{t-1} - p_{t-1}^*)}{2}\right] + n(y_t - y_t^n) + r(\Delta m_t - \Delta m_t^n)$, $\quad \Delta m_t^n = p_t^* + \Delta rm_t^n$

However, neither does this replacement change our main results. (Estimation results are

[35] See Orphanides and Wieland (2000) for this specification.

[36] See Gerdesmeier *et al*. (2002).

omitted.[37])

Overall, these results suggest that the effectiveness of monetary base channel is very uncertain, and we cannot find any certain route through which the central bank can provide stimulus to the economy at zero interest rates.

Case 2 Effect of Increase in Monetary Base on Inflation

Following Gerdesmeier *et al*. (2002) and Gerlach and Svensson (2000), we replace the Phillips curve (8) with the following P-star model (henceforth P*) as an aggregate supply function.[38]

(AS-AMP)
$$\Delta p_t = q\,\Delta p_{t-1} + (1-q)\,\Delta p^*_{t-1} + l\,(p^*_{t-1} - p_{t-1}) + h_t^{AS} \qquad (15)$$

where
$$p^*_t = m_t - a\, y^n_t + b\log\left(\frac{i^n_t}{1+i^n_t} + d\right) - g$$

$$p^*_t - p_t = rm_t - \left[a\, y^n_t - b\log\left(\frac{i^n_t}{1+i^n_t} + d\right) + g\right].$$

The P* model assigns an active role to monetary developments in inflation dynamics. Although the microeconomic foundations of the P* model are not well developed, the model can be implicitly related to the view that monetary disequilibria result in greater spending and thus more demand pressures (e.g. Laidler (1998)).[39] Specifically, inflationary pressure is related to the real money gap ($p^*_t - p_t$), which measures the excess of real money over that consistent with monetary equilibrium. Prices revert to the level implied by monetary equilibrium through an error correction process.[40]

Conducting rolling regressions using GMM, we estimate equations (7), (9), (10), and (15). Estimation results are shown in Chart 21. The sensitivity of the inflation rate to the real money gap (l) is significantly positive when it is estimated over the subsample excluding the recent five years (1978:1-1997:1). However, it has continued to decline for the past five years.

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[37] The estimation results are available on reader's request.

[38] The P* model is originally proposed in Hallman *et al*. (1991).

[39] More generally, the P* model can be seen as a reduced form representing a monetary transmission with a long pedigree, namely one that places imperfections in the financial system, monetary expansions and the resulting credit booms and busts at the heart of explanations of macroeconomic developments (e.g. Friedman and Schwartz, 1982; Kindleberger, 1987; Minksy, 1982).

[40] Gerlach and Svensson (2000), Kimura (2001), and Orphanides and Porter (2000) apply the P* model to Europe, Japan, and the US, respectively. They all find that real money gap is a significant determinant of inflation.

Parameter l estimated over the full sample (1978:1-2002:1) is very close to zero. In addition, the sensitivity of the inflation rate to the change in the price level implied by monetary equilibrium, 1-q, has also continued to decline. Since the estimated parameter reflects the average effectiveness of the monetary base channel during the long sample period, such a drastic decline in parameters l and 1-q may imply that the monetary base channel has hardly worked in the recent period, that is, at zero interest rates. Such an interpretation is consistent with the result of the time-varying VAR in Section 4.2.

Case 3 Effect of Increase in Monetary Base on Aggregate Demand and Inflation

Finally, consider the case combining Case 1 and Case 2. We assume that monetary base is a determinant of both aggregate demand and aggregate supply by using equations (11) and (15). Estimation results are shown in Chart 22. The sensitivity of the output gap to the change in monetary base (x) is not statistically significant, or does not have the expected sign. Like the results of Case 2, parameters l and 1-q in the P* model have continued to decline for the past five years.

In sum, the results of this section suggest that the effectiveness of the monetary base channel is highly uncertain and very small, if any. We cannot find any certain route through which the central bank can provide stimulus to the economy at zero interest rates.

7. Discussion

The results reported in the last two sections indicate that there is a satiation level of money demand and thus there may remain room for the monetary base channel to work even at zero interest rates, but that its effect is very uncertain and small, if any. Why is it so uncertain and small? We first need to point out that since long-term interest rates were already at a very low level when the Bank of Japan adopted quantitative easing, room for further reducing them through monetary policy was limited, which is a factor weakening the expectation channel. In addition, Japan’s economy has faced various kinds of uncertainties about the future course, including NPL problem and structural adjustment of the economy as well as short-run global economic outlook. These uncertainties have increased the risk premium of a wide range of financial and real assets, which seem to far exceed the quantitative magnitude of the effect of an increase in monetary base. Let us briefly discuss two more hypotheses of the uncertain and small effects of the monetary base channel, focusing on a structural aspect of Japan's financial market in recent years.

The first is that precautionary demand for money reflecting financial system instability is highly volatile, which weakens the effect of the monetary base channel and makes its effect uncertain. Precautionary demand for liquidity increased substantially at the end of 1999 in preparation for the Y2K problem and in early 2001 during the process of introducing real-time gross settlement (RTGS). It also increased in September 2001 because of the terrorist attacks in the US, the bankruptcy of a large retailer, and a fall in stock prices raising concerns over liquidity. Given a supply of monetary base, the increase in precautionary demand for money reduces excess money which would otherwise be translated into demand for other assets and, ultimately, via effects on relative yields, into nominal spending.

The second hypothesis is that concerns about capital positions at private banks prevent them from taking risks, which fails in raising the relative price of risky assets and weakens the effect of the monetary base channel. The quantitative easing measures since March 2001 have not apparently changed banks' lending behavior. Specifically, the declining trend in bank lending has mildly accelerated, while the growth in money stock, deposits held by households and corporations, has changed little at an annual rate of around 3 percent. The decline in bank lending and moderate growth in deposits should result in an increase in some other investment. So far, banks have increased investment in government bonds and current accounts at the Bank of Japan, both of which are free of credit risks. Then, why has bank lending not increased? Financial institutions have faced the risk of their capital being impaired by external factors such as an accumulation of NPLs following a downturn in asset prices and the restructuring of industries and firms. Capital is the buffer against unexpected risks and losses. It is difficult for the management of financial institutions to take risks when they are concerned about their capital position. Therefore, the Bank's efforts to expand liquidity, current account balances at the Bank or monetary base, do not lead to an increase in broad money, that is liquidity held by the corporate and household sectors, and consequently do not push up prices and the level of business activity.

In sum, money cannot play a role of the superior index of monetary policy effects, at least not when precautionary demand for money is highly volatile or banks cannot take risks due to concerns about their capital position.

Still, a question may remain: even if the effects of the monetary base channel are very uncertain and small, why does the Bank not aggressively try the "unconventional" policy of purchasing some specific assets such as stocks and property in order to affect their prices? The problem is that, to have any promise of significant results, such unconventional policy operations would likely need to be implemented on a very large scale. However, beyond the fact that it would have to be very large, next to nothing is known about the magnitude of monetaization required to achieve a given result. Moving in this direction is understandably difficult, since the cost of such unconventional policies increases substantially when uncertainty about the effects of the monetary base channel is taken into account.[41]

8. Concluding Remarks

The Bank of Japan adopted a new monetary easing framework in March 2001. It is still too early to draw definite conclusions on the effects of the framework and, in this regard, conclusions in this paper are tentative until more data become available. As mentioned at the outset, the current state of Japan's economy is unprecedented in that it is confronted with both a zero interest rate boundary and sizable NPLs, and thus we will continue to examine the tentative conclusions of this paper by cross-checking them in light of facts and theories.

As to the most evident effects, we can point out that the abundant and flexible provision of liquidity under the quantitative easing framework successfully maintained extremely easy monetary conditions, thereby preserving financial market stability. Recall the difficulties we have experienced since the end of 2000, namely, a global economic retreat triggered by the bursting of the global IT bubble and the tragic events of September 11. Additionally, Japan suffered from the adverse impact of structural adjustment and rising concerns over the financial system. It is thus significant that the Bank's flexible and abundant provision of liquidity calmed down market participants' concerns over liquidity financing. There is little doubt such accommodative monetary conditions played a key role in avoiding a deflationary spiral.

Apart from this role in mitigating negative impacts, what other positive effects has the increase in monetary base had on the economy? While we can enumerate several routes of the

[41] Another essential issue with respect to unconventional policy is the governance of a central bank in a democratic society. If a central bank purchases a variety of assets aggressively as a monetary policy, it is effectively stepping into the territory of fiscal policy. The reason is that the bank has to incur a loss by subsidizing to specific parties or by holding risky assets, which will be transferred to taxpayers in the end, and engages in micro policy regarding resource allocations. See Yamaguchi (2001) for details.

monetary base channel which suggest that expansion of monetary base can have some expansionary effect on the economy, our analyses suggest the quantitative magnitude of any such effect is highly uncertain and very small, if any. Of course, we still cannot deny the possibility that the positive effect will increase and lead to a change in the portfolios of economic agents and ultimately stimulate economic activity in the long run. Once structural reforms such as the disposal of NPLs and the adjustment of industry-wide structure progress to a satisfactory degree, the quantitative easing policy will support them by alleviating the negative shocks occurring in a transition period, and might have stronger effects on the economy.[42] Based on the analysis of the policy effects and the economic situation, it should be discussed what macro and micro economic policy should be sought for Japan's economy.

[42] On October 11, 2002, the Policy Board of the Bank of Japan approved basic guidelines on the purchase of stocks held by commercial banks. This approval was made in response to the Bank's announcement of September 18, 2002 ("New Initiative Toward Financial System Stability"), in which the Bank announced that it would explore possible policy measures to enhance financial institutions' efforts to reduce their shareholdings. The Bank does not regard the purchase of stocks as a liquidity provision measure in the form of monetary policy, and its decision is based on the understanding that market risk pertaining to the shareholdings of Japanese banks has become a significant destabilizing factor for their management. The Bank also published a comprehensive review of the NPL problem entitled "Japan's Nonperforming Loan Problem" on October 11, which also responded to "New Initiative". The purpose of these actions is to facilitate resolution of the NPL problem and to secure the financial system stability.

Data Appendix.

(1) Monetary base m_t

Seasonably adjusted by X12-ARIMA. The change in the reserve requirement ratio is also adjusted.
Source: Bank of Japan, "Financial and Economics Statistics Monthly."

(2) Output y_t

Real GDP seasonally adjusted by X12-ARIMA.[*] Outliers are adjusted at 1989:1 and 1997:1. This adjustment is aimed at capturing the temporary surge in demand ahead of the consumption tax hike.
Source: Cabinet Office, "National Accounts."

(3) Potential output y_t^n

Estimated by using the Hodrick-Prescott filter on y_t .

(4) Overnight call rate i_t

Uncollaterized rate (monthly average) is used for the sample after 1985:1, while collaterized rate (monthly average) is used for that before 1984:4.
Source: Bank of Japan, "Financial and Economics Statistics Monthly."

(5) Price level p_t and inflation rate Δp_t

GDP deflator seasonally adjusted by X12-ARIMA.[*] Level shifts are adjusted at 1989:2 and 1997:2. This adjustment is aimed at capturing the upward shift due to the consumption tax hike.
Source: Cabinet Office, "National Accounts."

(6) The Bank's inflation target p_t^*

We assume that the target range of inflation rate ranges between 0.5% and 2.5% and that the target rate has a smooth underlying trend. Then, we estimate the following sigmoid function.

$$\pi_t = \pi_t^* + \zeta_t \quad , \quad \pi_t^* = 2.5 - \frac{2}{1+\exp[\rho(T-t)]}, \qquad \rho > 0 ,$$

where z_t is the error term. For very large r, p_t^* essentially collapses to a step function that equals 2.5% when $t<T$ and equals 0.5%(=2.5-2) when $t>T$. In this case, the estimate of T offers the best estimated location of the structural break. We estimate this sigmoid function by non-linear least squares. The estimated midpoint of the transition (determined by T) is 1987/2Q. The estimated value of parameter r is 0.139.

(7) Inflation rate, interest rate, and the growth rate of monetary base are all measured in percent at an annual rate.

[*] The sample after 1980:1 is based on 93SNA, while that before 1979:4 is based on 68SNA.

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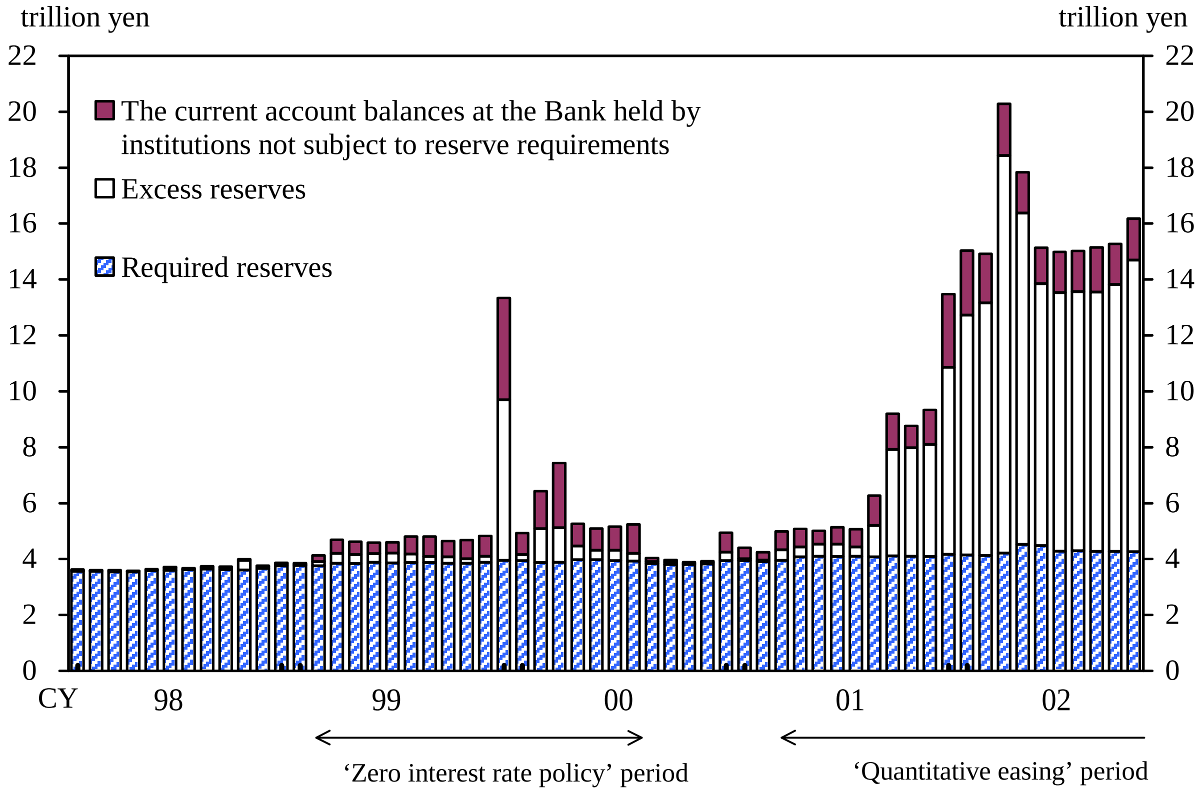
Chart 1

Current Account Balances at the Bank of Japan

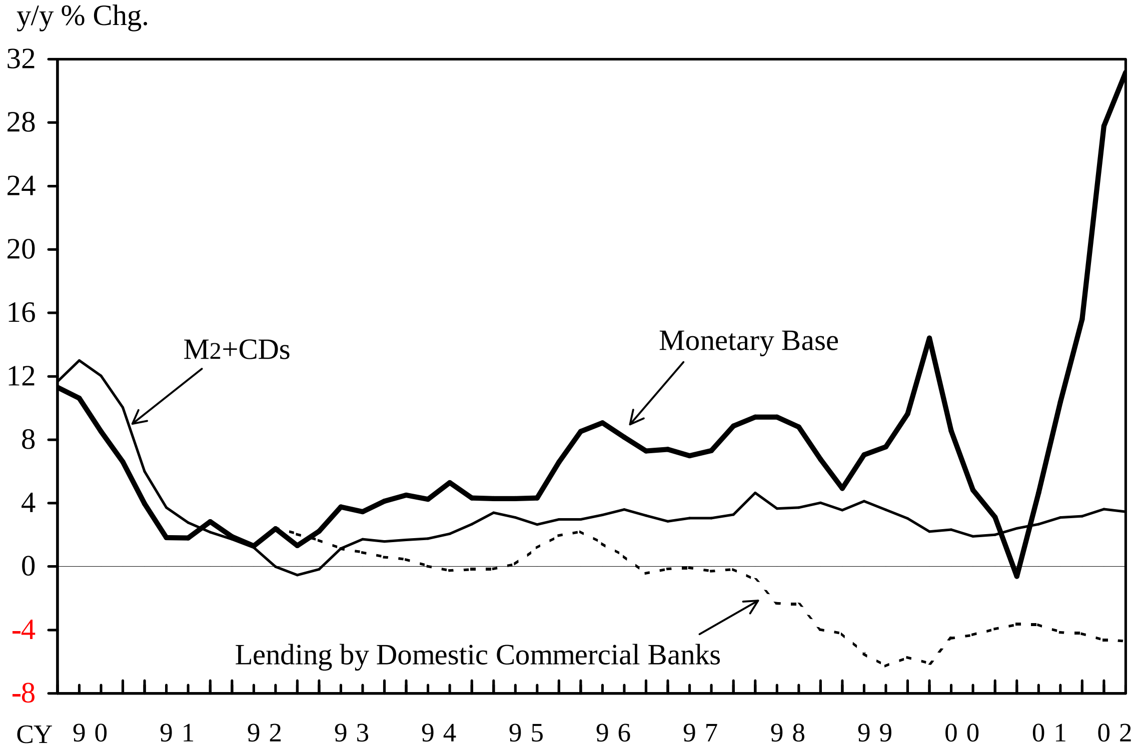


Note: Each month indicates a reserve maintenance period (from 16th of one month to the 15th of the following month).

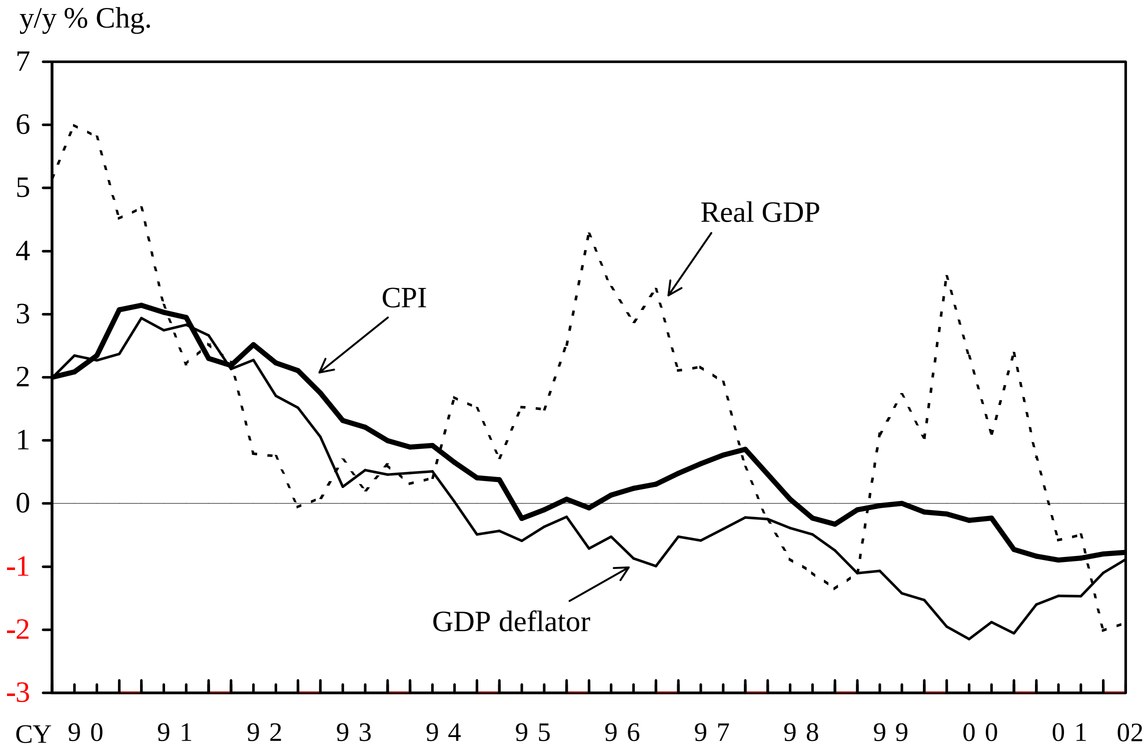
Source: Bank of Japan, "Financial and Economic Statistics Monthly."

Money, Inflation and Output

(1) Monetary Base, M2+CDs, Lending



(2) CPI, GDP deflator, Real GDP



Note: CPI, GDP deflator and Real GDP are adjusted to exclude the effects of the consumption tax hike in April 1997.

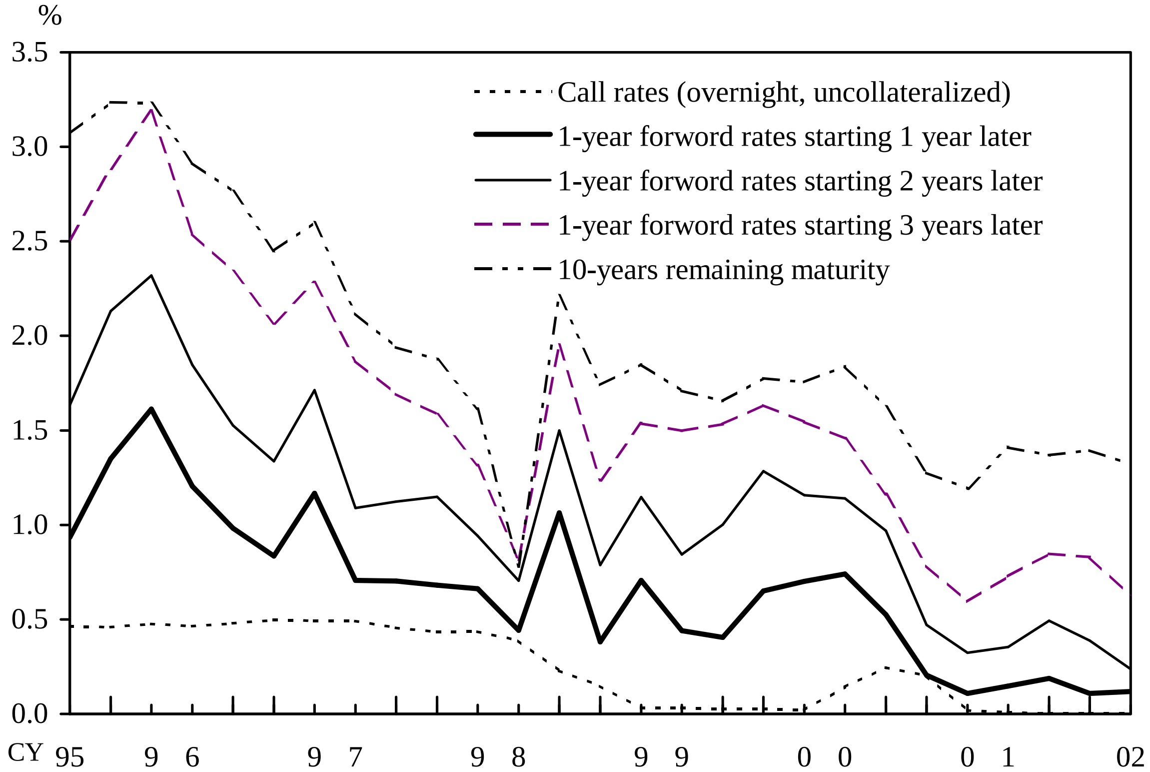
Sources: Bank of Japan, "Financial and Economic Statistics Monthly,""Principal Figures of Financial Institutions"; Ministry of Public Management, Home Affairs, Posts and Telecommunications, "Consumer Price Index"; Cabinet Office, "National Accounts."

Call Rates (Overnight)

Source: Bank of Japan, "Financial and Economic Statistics Monthly."

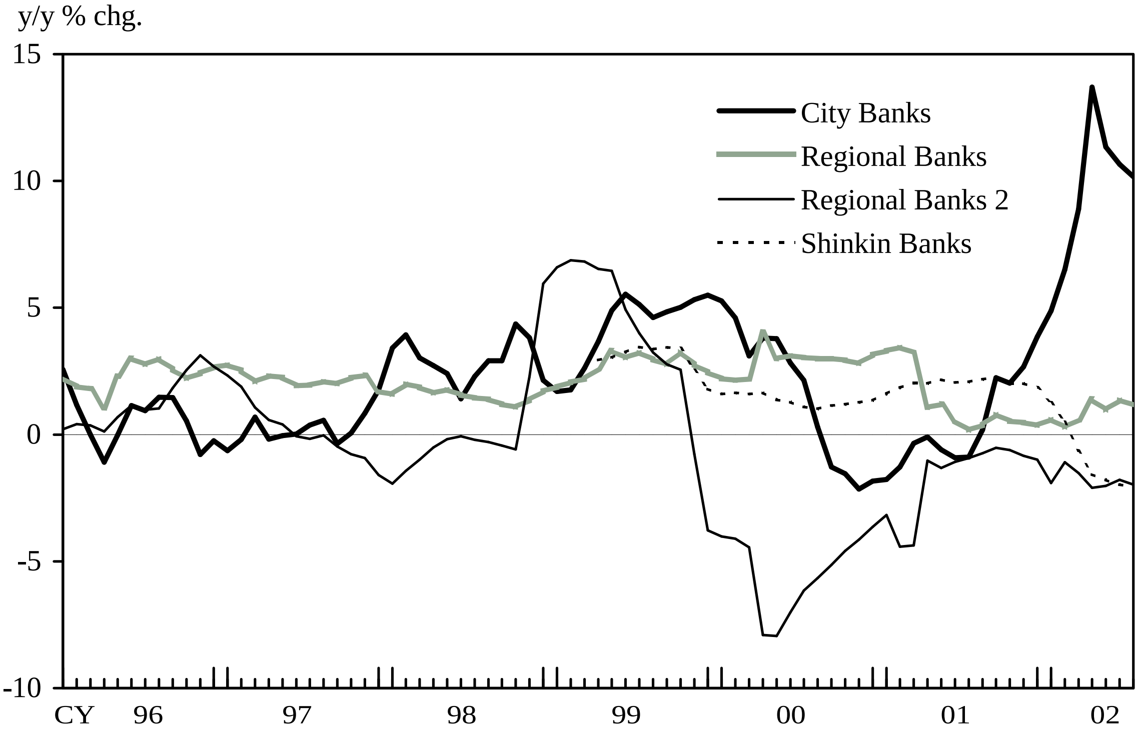
Chart 4

Forward Rates of Government Bond Yields



Source: Bank of Japan, "Financial and Economic Statistics Monthly."

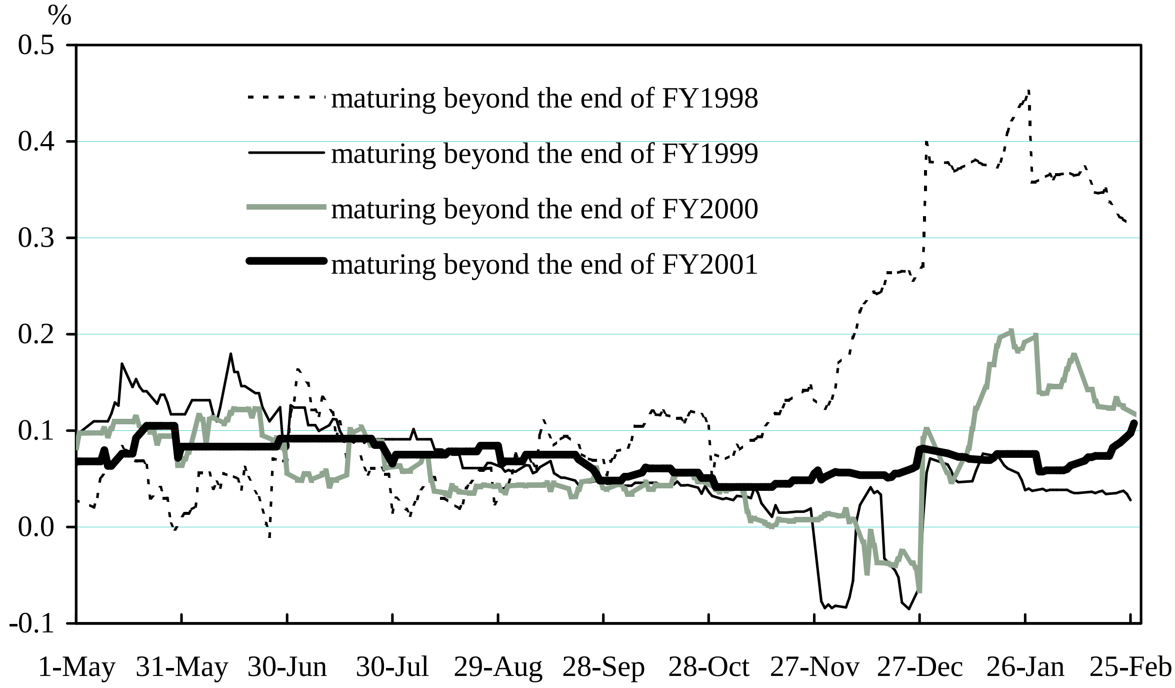
Deposits of Domestically Licensed Banks



Source: Bank of Japan, "Economic and Financial Data on CD-ROM."

Chart 6

Premium of Euro-yen Rates Maturing beyond the End of Fiscal Year



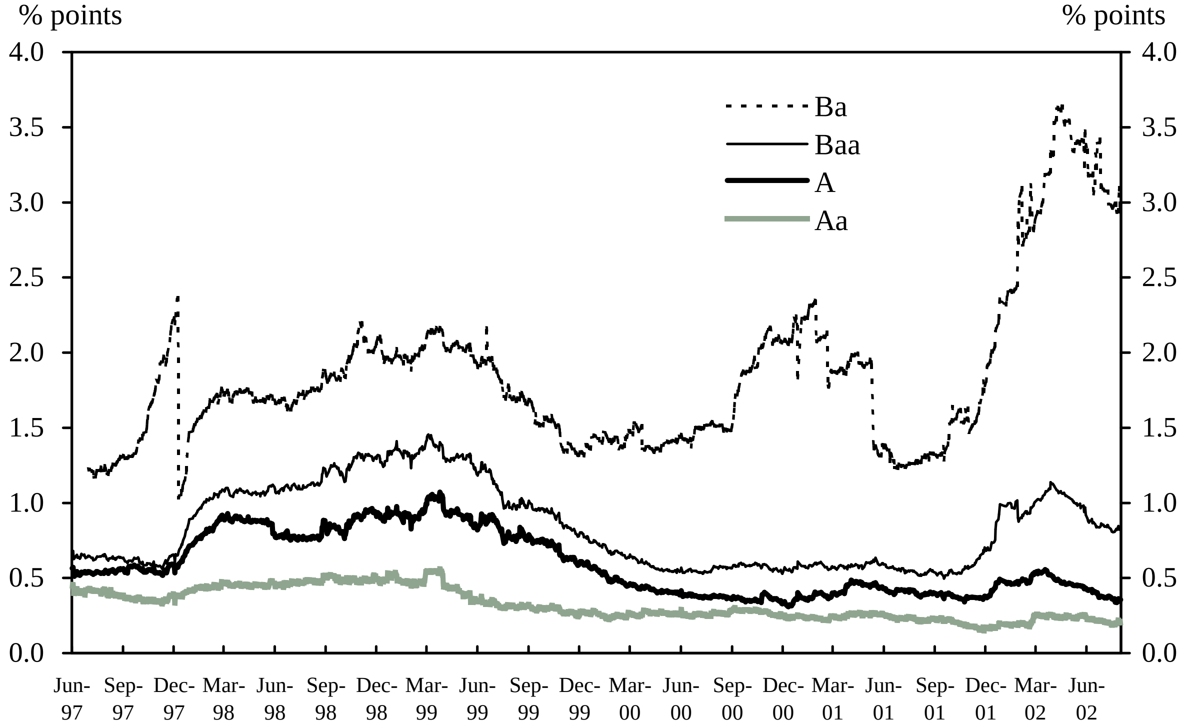
Note: Premium here is the rate increase in funding liquidity when the maturity steps over the end of fiscal year.

Premium = (Implied forward rates from March to April) – (One-month implied forward rates whose contracts expire within the same fiscal year : Average of those from February to March and those from April to May)

Source: Japanese Bankers Association

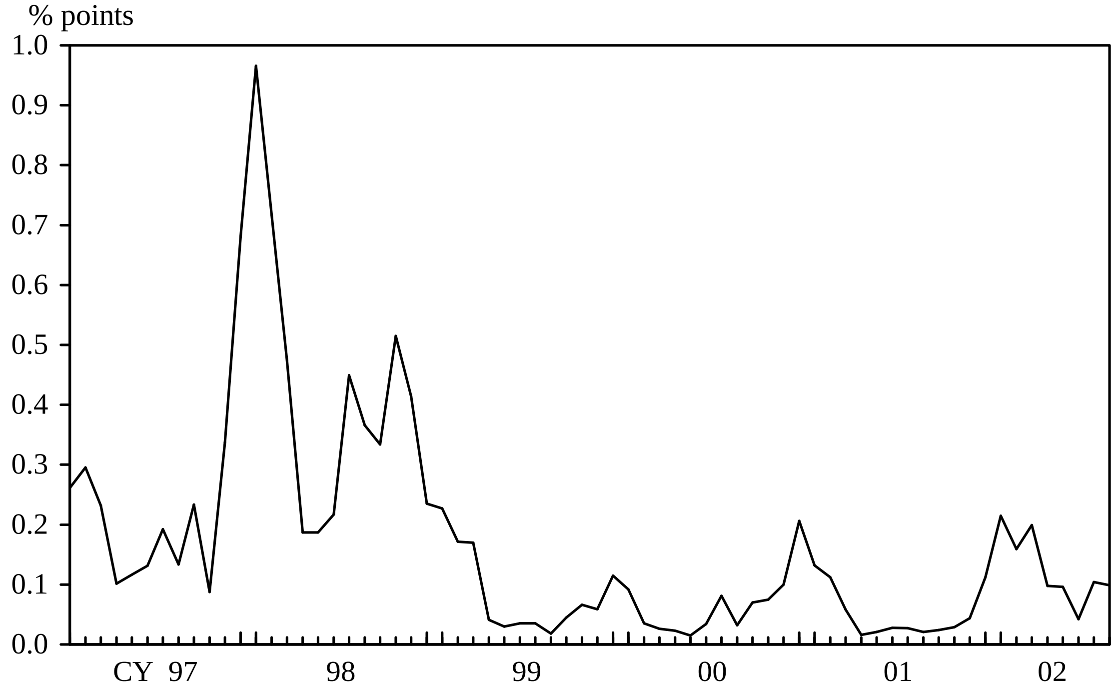
Yield Spreads of Corporate and Public Bonds

(1)Yields on Corporate Bond - Yields on Government security



Note: Yields on bonds with 5-year maturity. The indicated ratings are of Moody's.
Source: Japan Securities Dealers Association, "Over-the-Counter Standard Bond Quotations," "Reference Price(Yields) Table for OTC Bond Transactions."

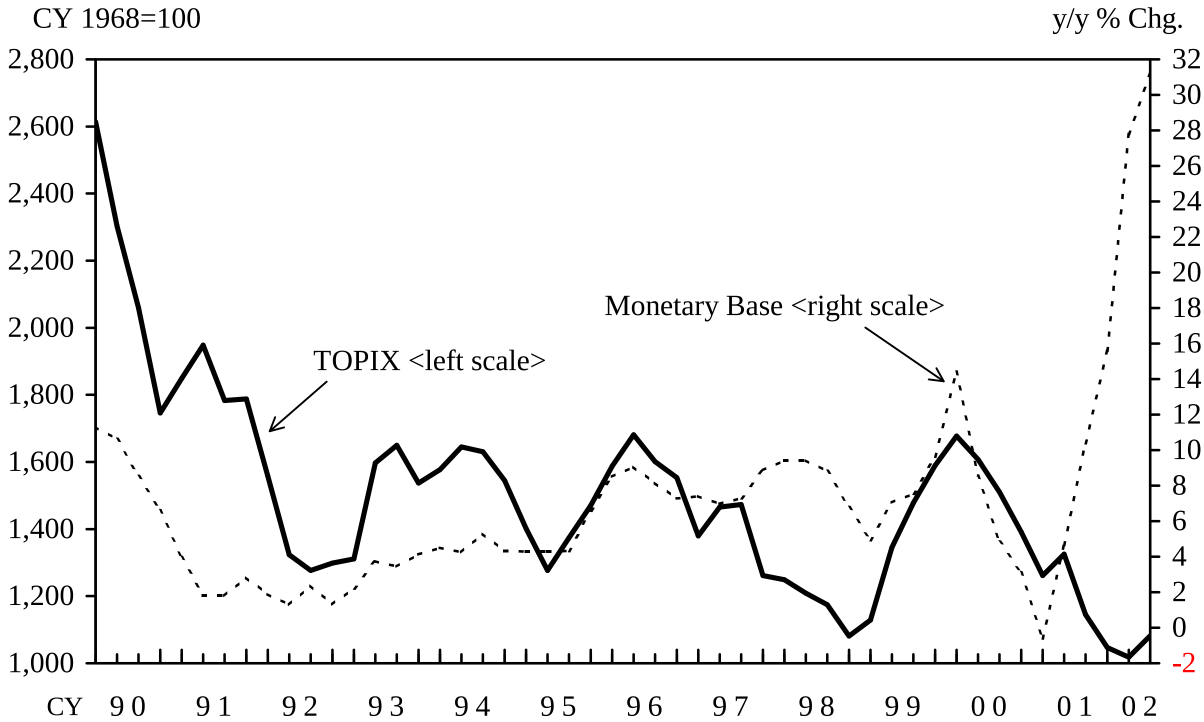
(2) Yields on Commercial Papers - Yields on Financing Bills



Note: Yields on FB until March 1999 are replaced with Yields on TB.
Source: Bank of Japan, "Financial and Economic Statistics Monthly."

Chart 8

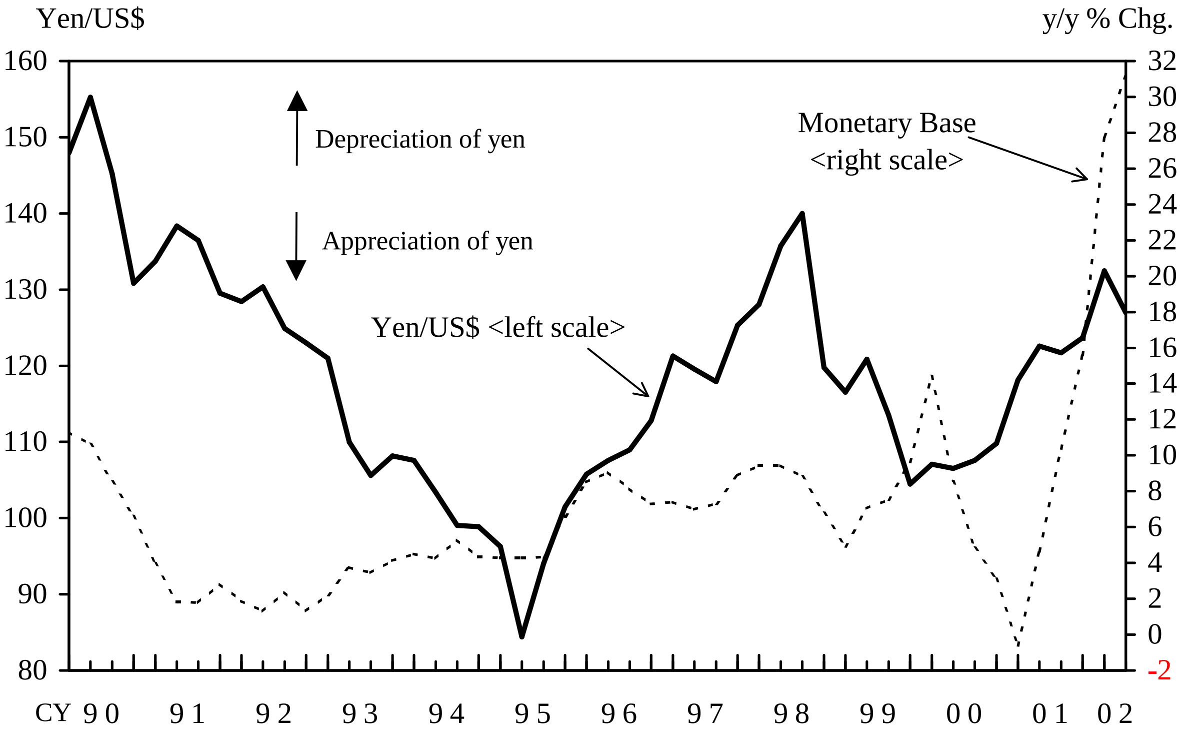
Stock Prices



Sources: Tokyo Stock Exchange, "Monthly Statistics Report";
Bank of Japan, "Financial and Economic Statistics Monthly."

Chart 9

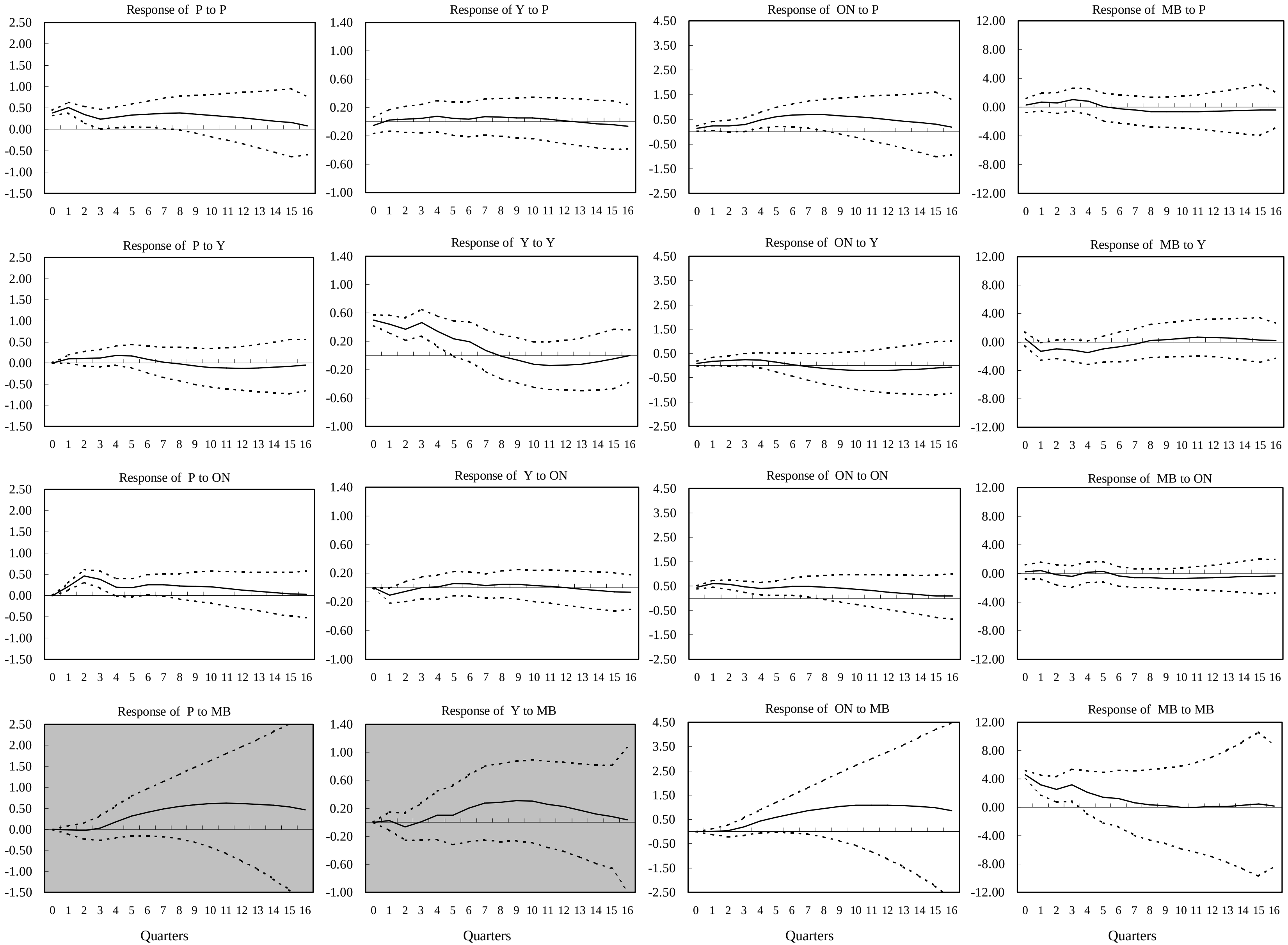
Exchange Rates



Source: Bank of Japan, “Financial and Economic Statistics Monthly.”

Impulse Response Functions based on VAR (Sample Period:1980:1-2002:1)

Y : Output gap
P : Inflation rate
ON : Uncollateralized Overnight Call Rate [level]
MB : Monetary Base [growth rate]

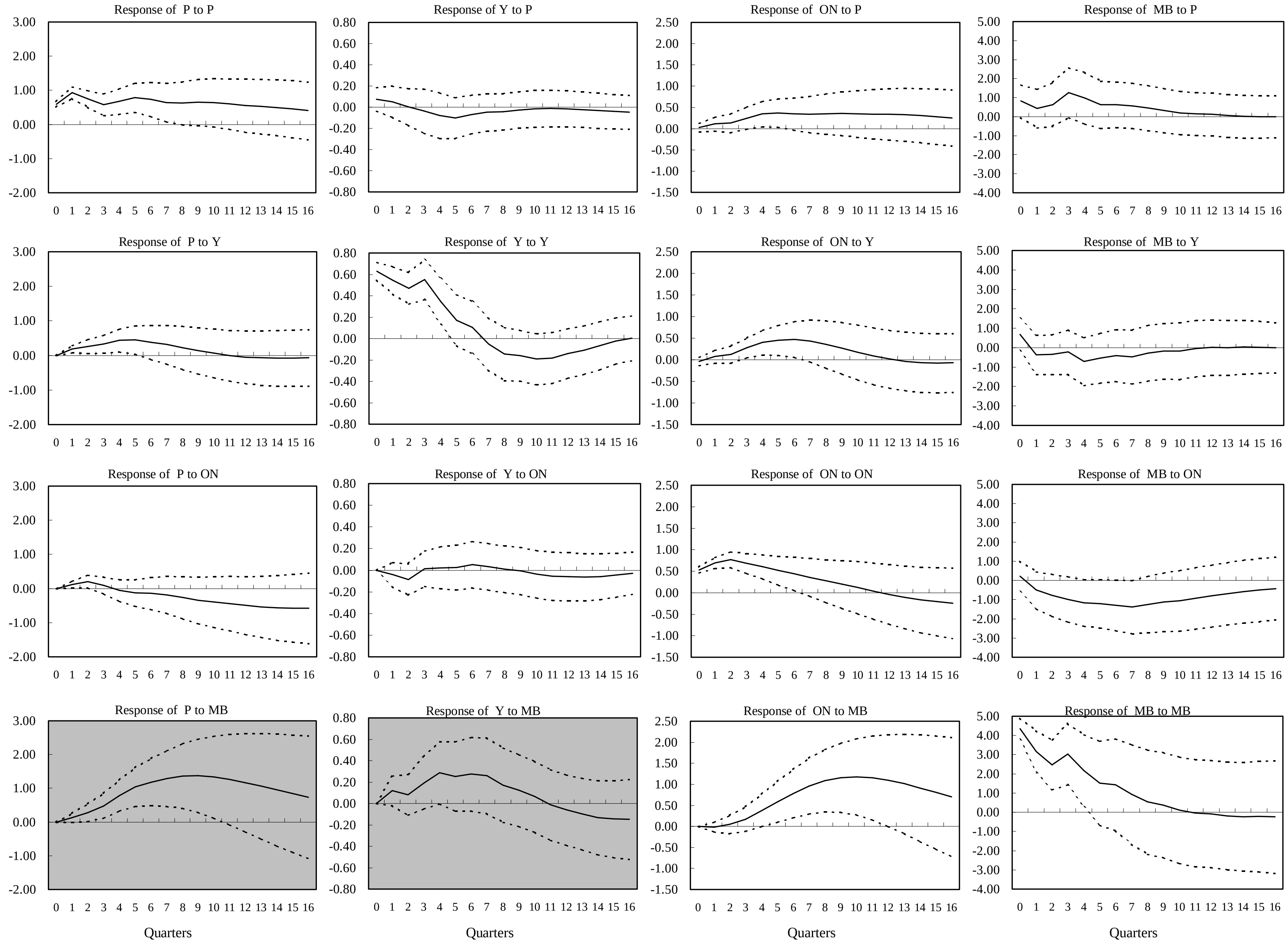


Note: The chart shows a sixteen-quarter response of variables to a one-standard deviation innovation. The dashed lines represent the plus/minus two standard deviation bands.

Chart 11

Impulse Response Functions based on VAR (Sample Period:1971:2-2002:1)

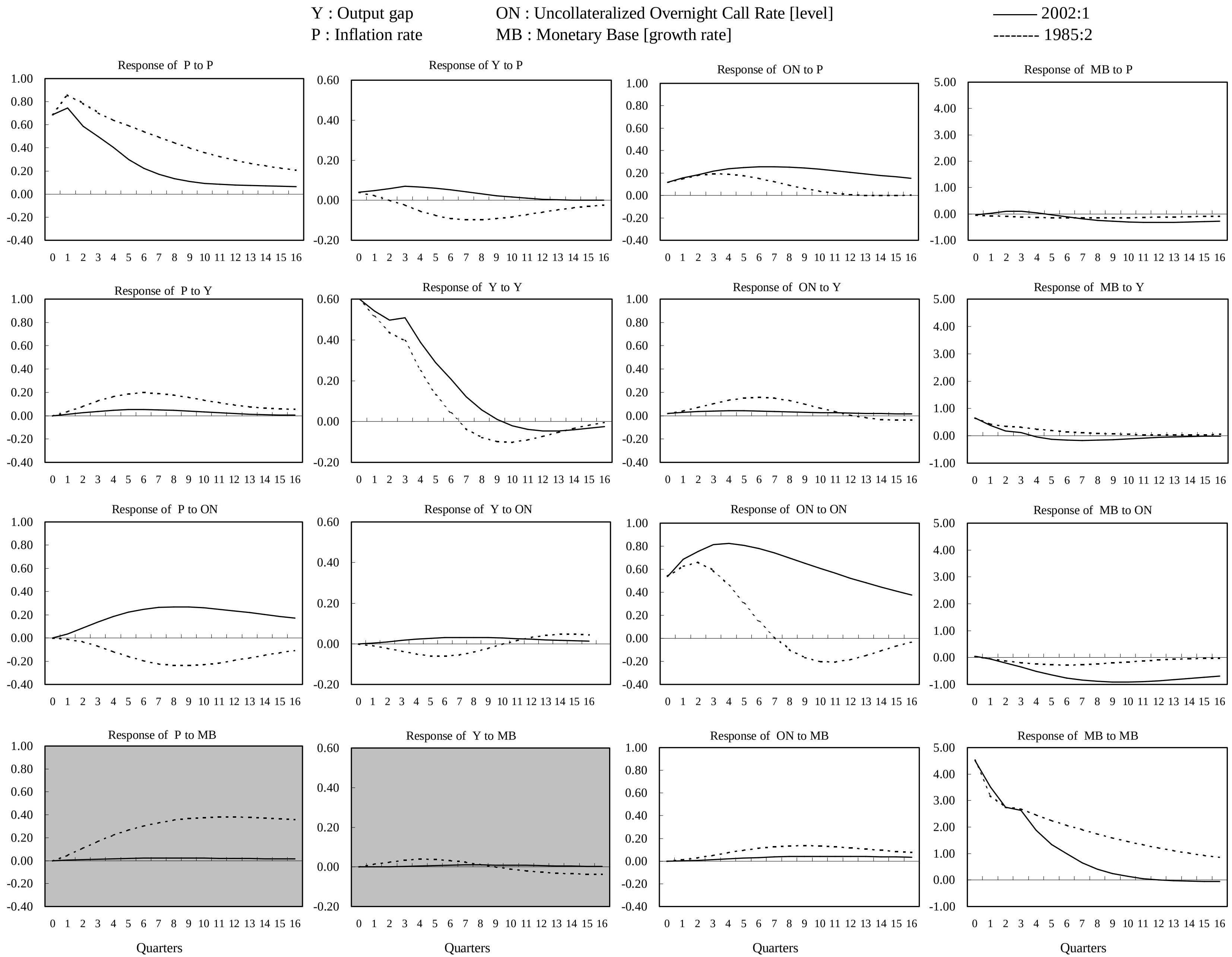
Y : Output gap ON : Uncollateralized Overnight Call Rate [level]
P : Inflation rate MB : Monetary Base [growth rate]



Note: The chart shows a sixteen-quarter response of variables to a one-standard deviation innovation. The dashed lines represent the plus/minus two standard deviation bands.

Impulse Response Functions based on Time-Varying VAR

Y : Output gap ON : Uncollateralized Overnight Call Rate [level]
P : Inflation rate MB : Monetary Base [growth rate]



Note: The solid line shows a sixteen-quarter response of variables at the time of 2002:1. The dashed line shows a sixteen-quarter response of variables at the time of 1985:2.

Johansen's Cointegration Test

(1) Series: $m_t - p_t$, y_t, i_t

Null hypothesis : rank = r	Maximum eigenvalue statistic	Trace statistic
$r = 0$	12.9 (21.0)	22.7 (29.7)
$r \leq 1$	8.8 (14.1)	9.8 (15.4)
$r \leq 2$	1.0 (3.8)	1.0 (3.8)

(2) Series: $m_t - p_t$, y_t, $\log(i_t)$

Null hypothesis : rank = r	Maximum eigenvalue statistic	Trace statistic
$r = 0$	14.4 (21.0)	25.7 (29.7)
$r \leq 1$	8.3 (14.1)	11.3 (15.4)
$r \leq 2$	3.0 (3.8)	3.0 (3.8)

Notes: 1. The sample period is 1978:1 to 2002:1.

2. Numbers in parentheses are critical values at the 5% significance level.

3. The lag-length of the VECM is set to 4 , obtained from the likelihood-ratio test.

Chart 14

Estimation Results of Equation (6)

$$\frac{k_t}{e^{g}(ii_t + d)^{-b}} - 1 = e_t \qquad (6)$$

$$\text{where} \quad k_t = \frac{M_t}{P_t Y_t^{a}}, \quad ii_t = \frac{i_t}{1 + i_t}$$

Parameter Restriction	a	b	g	d	s.e.	J-test	LR(1)
unrestricted	0.924	0.137 (0.012)	-1.869 (0.046)	0.000155 (0.000127)	0.0874	5.520 [0.479]	——
$d = 0$	0.924	0.115 (0.091)	-1.784 (0.039)	——	0.0864	11.980 [0.101]	6.460 [0.011]

Notes:
1. This table reports GMM estimates of the parameters of Equation (6). The sample period is 1978:1 to 2002:1. Instruments used include four lags of k_t, four lags of ii_t, and a constant term. A four-lag Newey-West estimate of the variance-covariance matrix is used. Numbers in parentheses are standard errors.
2. Due to difficulty in calculation convergence, the estimation of the parameter a is carried out by a grid search method. The search is carried out over the range $0.5 \leq a \leq 1.5$ at intervals of 0.001.
3. The column J-test corresponds to the Hansen test of the overidentifying restrictions. Numbers in brackets are p-values, for testing the null hypotheses.
4. The column LR(1) corresponds to the likelihood-ratio-type test of the parameter constraint $d = 0$. The number in brackets is a p-value, for testing the null hypothesis $d = 0$.

Chart 15

Money Demand Function : Estimated Curves and Actual Data

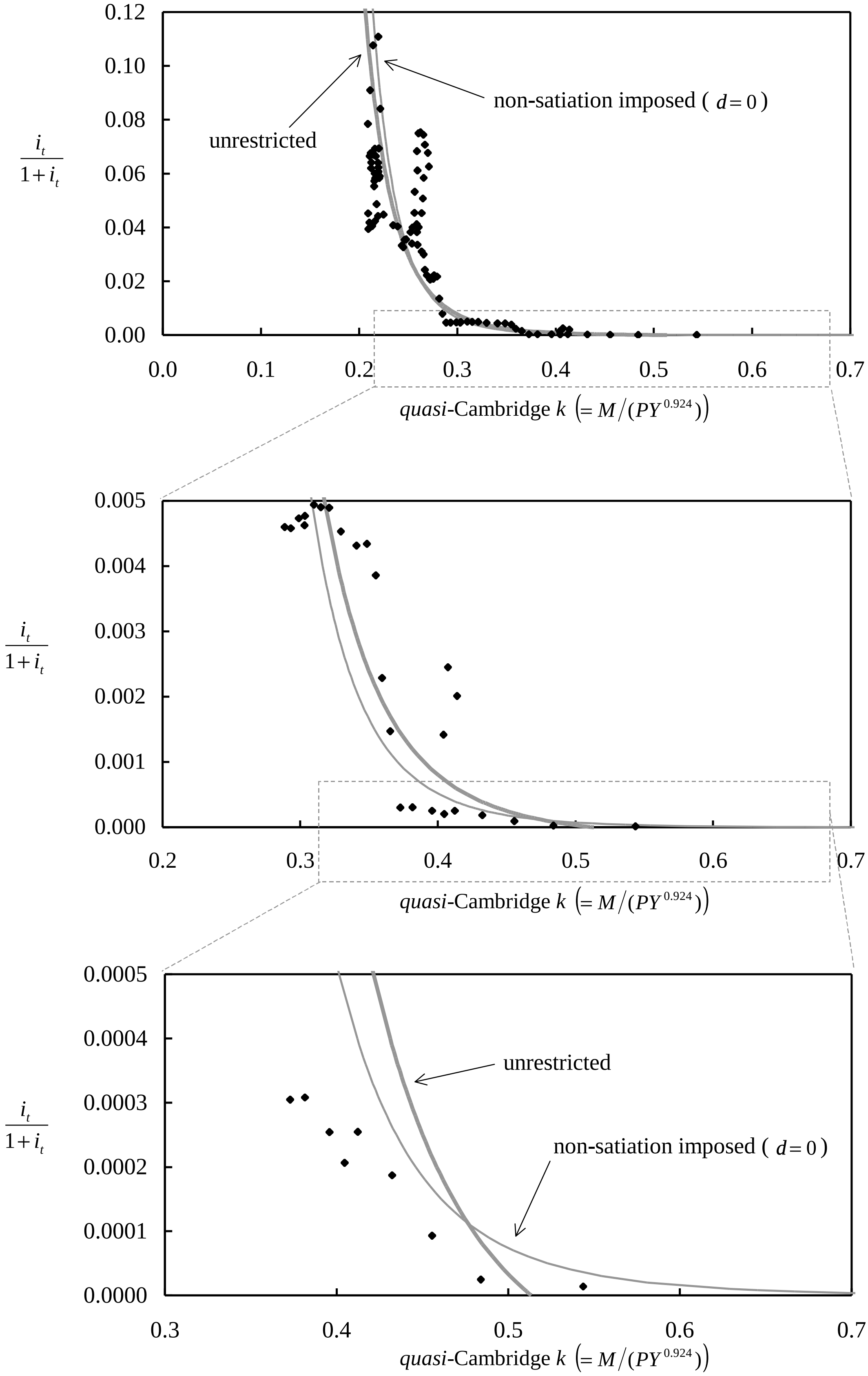
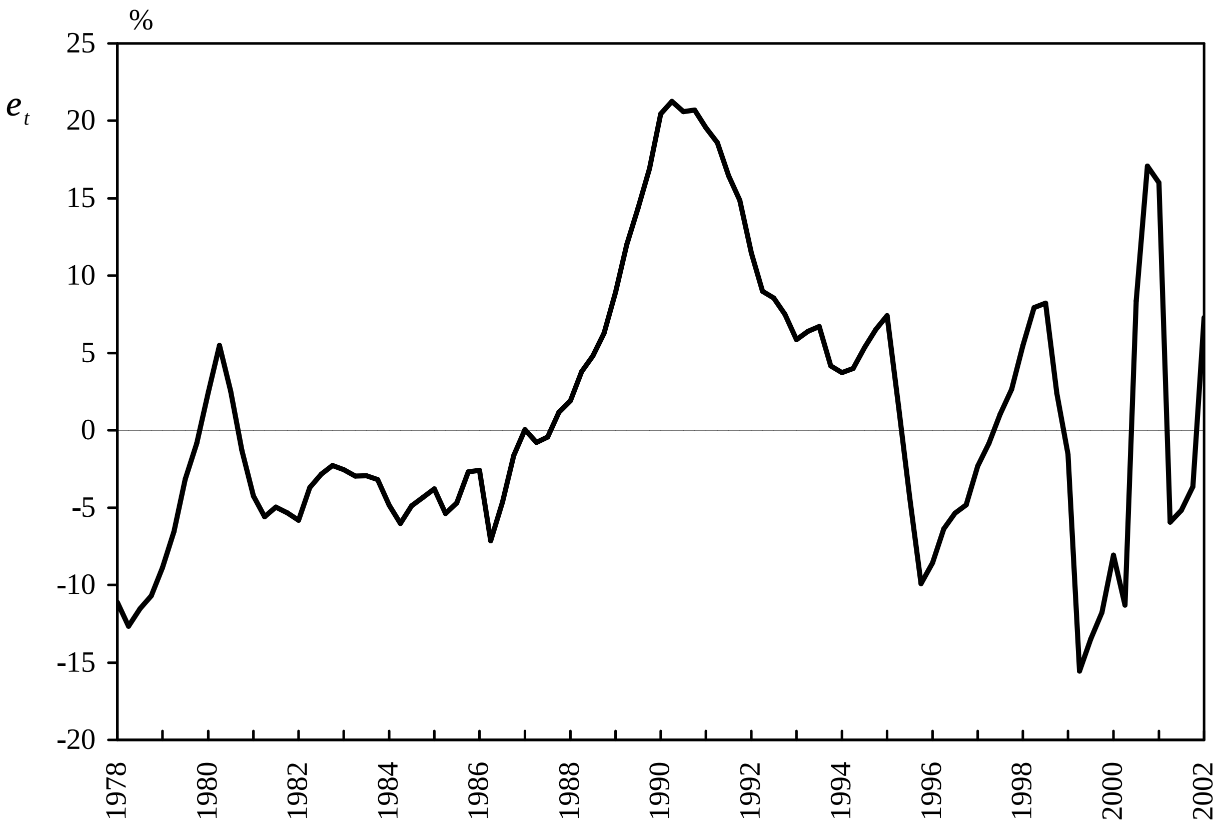


Chart 16

Percent Deviation of Actual Money Balances from Long-run Desired Money Balances



Unit Root Tests

ADF test			Phillips-Perron test		
Lags	Statistics	*p*-value	Lags	Statistics	*p*-value
4	-2.906	0.004	4	-13.412	0.011

Notes: 1. The null hypothesis is that the e_t follows a unit root process.

2. The sample period is 1978:1 to 2002:1.

Passive Money Paradigm

$$\text{(AD)} \quad y_t - y_t^n = f\,(y_{t-1} - y_{t-1}^n) - s\,\left(i_{t-1} - E_{t-1}[D\,p_t] - r_{t-1}^n\right) + h_t^{AD} \qquad (7)$$

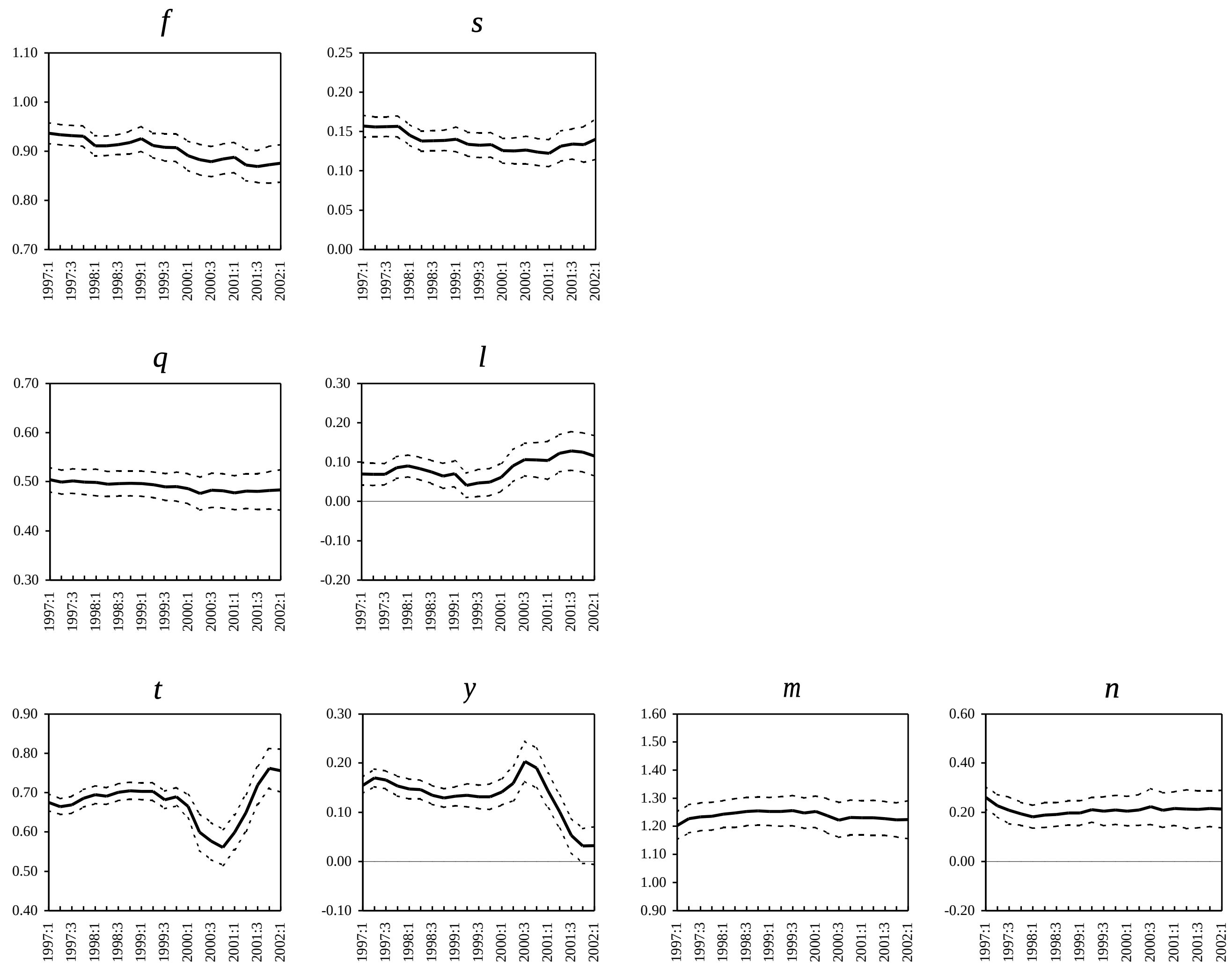
$$\text{(AS)} \quad D\,p_t = q\,D\,p_{t-1} + (1-q)\,D\,p_{t-2} + l\,(y_{t-1} - y_{t-1}^n) + h_t^{AS} \qquad (8)$$

$$\text{(LM)} \quad D\,rm_t - D\,rm_t^n = t\,(D\,rm_{t-1} - D\,rm_{t-1}^n) - y\,(e_{t-1}) + h_t^{LM}\ , \qquad (9)$$

$$\text{where} \quad e_t = rm_t - a\,y_t + b\,\log\left(\frac{i_t}{1+i_t} + d\right) - g$$

$$\text{(MP)} \quad i_t = \frac{i_t^* + \sqrt{(i_t^*)^2 + w}}{2} + h_t^{MP}\ , \qquad (10)$$

$$\text{where} \quad i_t^* = i_t^n + m\left[\frac{(D\,p_t - p_t^*) + (D\,p_{t-1} - p_{t-1}^*)}{2}\right] + n\,(y_t - y_t^n)$$



Notes: 1. This chart shows estimates of parameters from rolling regressions with the horizontal axis showing the end of sample for each regression. The starting point of regression is fixed at 1978:1.

2. Dotted lines show the interval estimates of ±2 standard errors.

3. Effects of the Y2K problem (2000/1Q) and the removal of blanket deposit insurance for time deposits, etc. (2002/1Q) are adjusted by dummy variables.

Active Money Paradigm [Case 1]

(AD-AMP) $$y_t - y_t^n = f\,(y_{t-1} - y_{t-1}^n) - s\,\left(i_{t-1} - E_{t-1}[D\,p_t] - r_{t-1}^n\right) + x\,(D\,rm_{t-1} - D\,rm_{t-1}^n) + h_t^{AD} \quad (11)$$

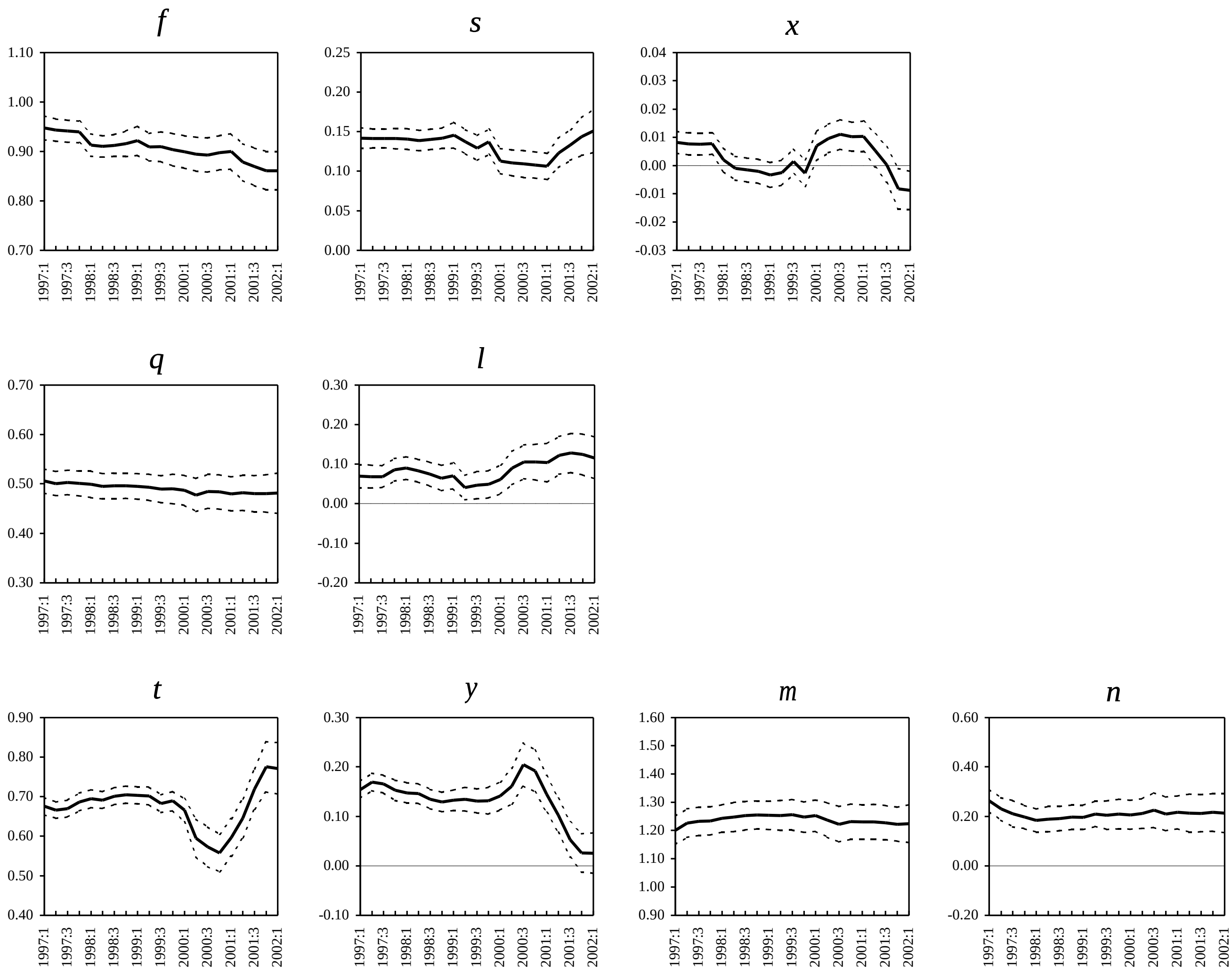
(AS) $$D\,p_t = q\,D\,p_{t-1} + (1-q)\,D\,p_{t-2} + l\,(y_{t-1} - y_{t-1}^n) + h_t^{AS} \quad (8)$$

(LM) $$D\,rm_t - D\,rm_t^n = t\,(D\,rm_{t-1} - D\,rm_{t-1}^n) - y\,\,(e_{t-1}) + h_t^{LM}\,, \quad (9)$$

where $$e_t = rm_t - a\,y_t + b\,\log\left(\frac{i_t}{1+i_t} + d\right) - g$$

(MP) $$i_t = \frac{i_t^* + \sqrt{(i_t^*)^2 + w}}{2} + h_t^{MP}\,, \quad (10)$$

where $$i_t^* = i_t^n + m\left[\frac{(D\,p_t - p_t^*) + (D\,p_{t-1} - p_{t-1}^*)}{2}\right] + n\,(y_t - y_t^n)$$



Notes: 1. This chart shows estimates of parameters from rolling regressions with the horizontal axis showing the end of sample for each regression. The starting point of regression is fixed at 1978:1.

2. Dotted lines show the interval estimates of ±2 standard errors.

3. Effects of the Y2K problem (2000/1Q) and the removal of blanket deposit insurance for time deposits, etc. (2002/1Q) are adjusted by dummy variables.

Robustness Check

(AD-AMP) $$y_t - y_t^n = f(y_{t-1} - y_{t-1}^n) - s\left(i_{t-1} - E_{t-1}[Dp_t] - r_{t-1}^n\right) + \sum_{k=1}^{4} x_k\,(Drm_{t-k} - Drm_{t-k}^n) + h_t^{AD} \quad (12)$$

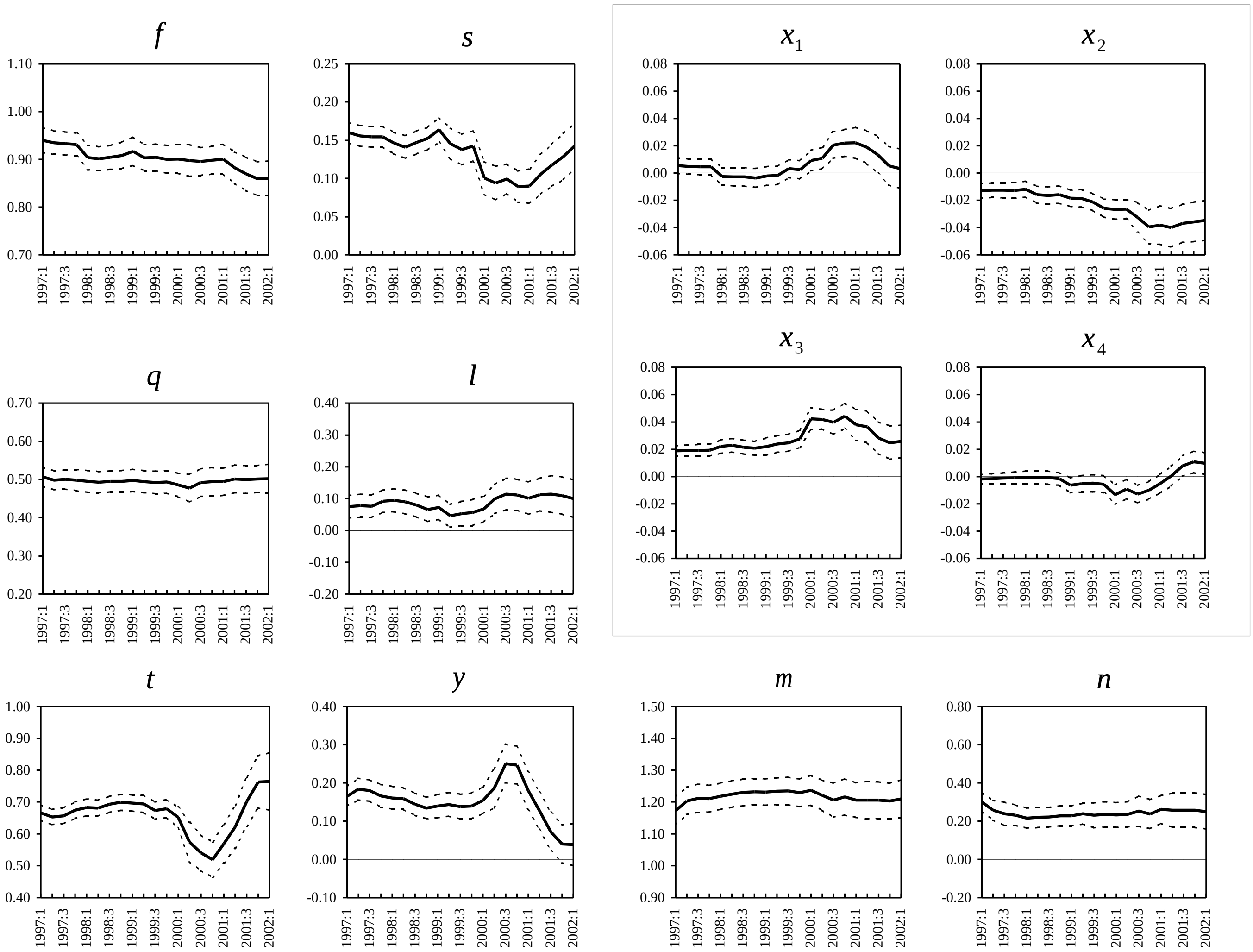
(AS) $$Dp_t = q\,Dp_{t-1} + (1-q)\,Dp_{t-2} + l\,(y_{t-1} - y_{t-1}^n) + h_t^{AS} \quad (8)$$

(LM) $$Drm_t - Drm_t^n = t\,(Drm_{t-1} - Drm_{t-1}^n) - y\,(e_{t-1}) + h_t^{LM}\ , \quad (9)$$

where $e_t = rm_t - a\,y_t + b\log\left(\dfrac{i_t}{1+i_t} + d\right) - g$

(MP) $$i_t = \frac{i_t^* + \sqrt{(i_t^*)^2 + w}}{2} + h_t^{MP}\ , \quad (10)$$

where $i_t^* = i_t^n + m\left[\dfrac{(Dp_t - p_t^*) + (Dp_{t-1} - p_{t-1}^*)}{2}\right] + n\,(y_t - y_t^n)$



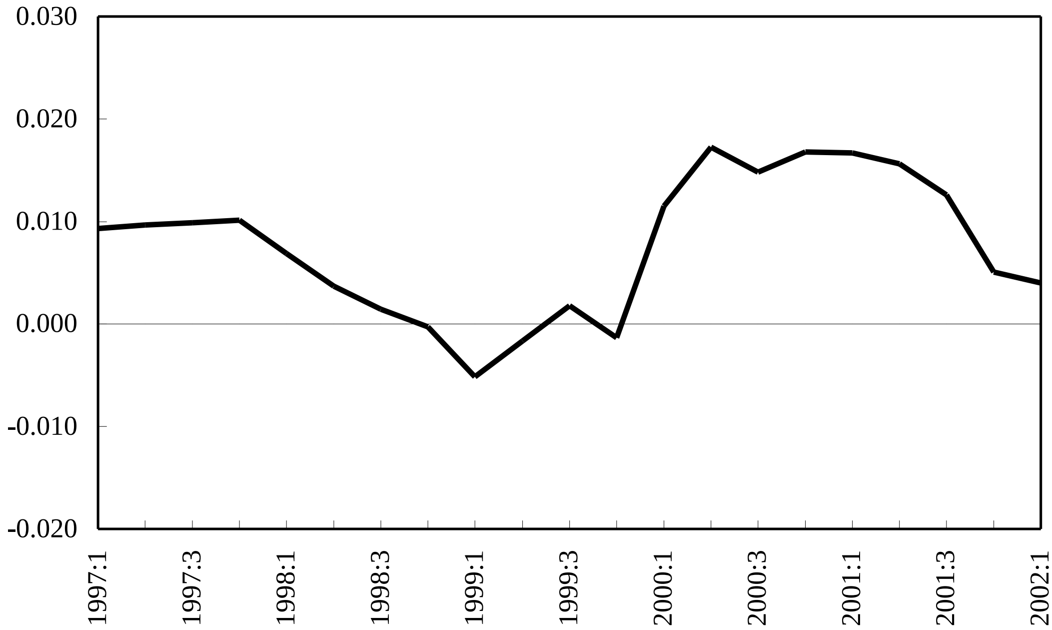
Notes: 1. This chart shows estimates of parameters from rolling regressions with the horizontal axis showing the end of sample for each regression. The starting point of regression is fixed at 1978:1.

2. Dotted lines show the interval estimates of ±2 standard errors.

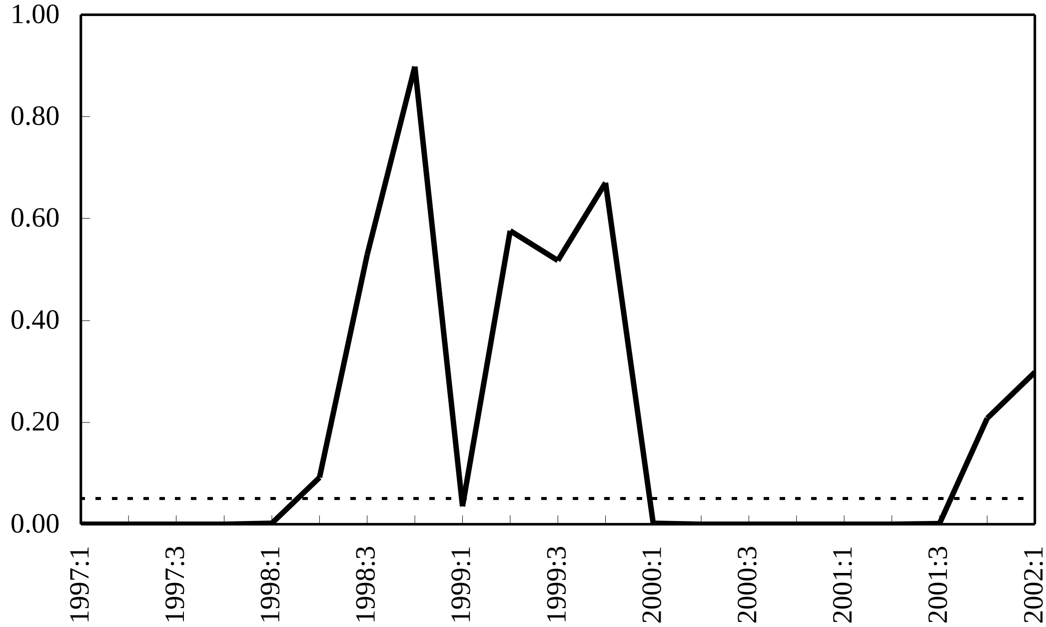
3. Effects of the Y2K problem (2000/1Q) and the removal of blanket deposit insurance for time deposits, etc. (2002/1Q) are adjusted by dummy variables.

Robustness Check

$\sum_{j=1}^{4} x_j$



***p*-values of** $H_0 : \sum_{j=1}^{4} x_j = 0$



Notes: 1. The *p*-values are based on the likelihood-ratio-type tests. The horizontal axis shows the end of sample for each test. The starting point of regression is fixed at 1978:1.

2. The dotted line shows the 5% significance level.

Active Money Paradigm [Case 2]

(AD) $$y_t - y_t^n = f(y_{t-1} - y_{t-1}^n) - s\left(i_{t-1} - E_{t-1}[Dp_t] - r_{t-1}^n\right) + h_t^{AD} \qquad (7)$$

(AS-AMP) $$Dp_t = q\,Dp_{t-1} + (1-q)\,Dp_{t-1}^* + l\,(p_{t-1}^* - p_{t-1}) + h_t^{AS}\ , \qquad (15)$$

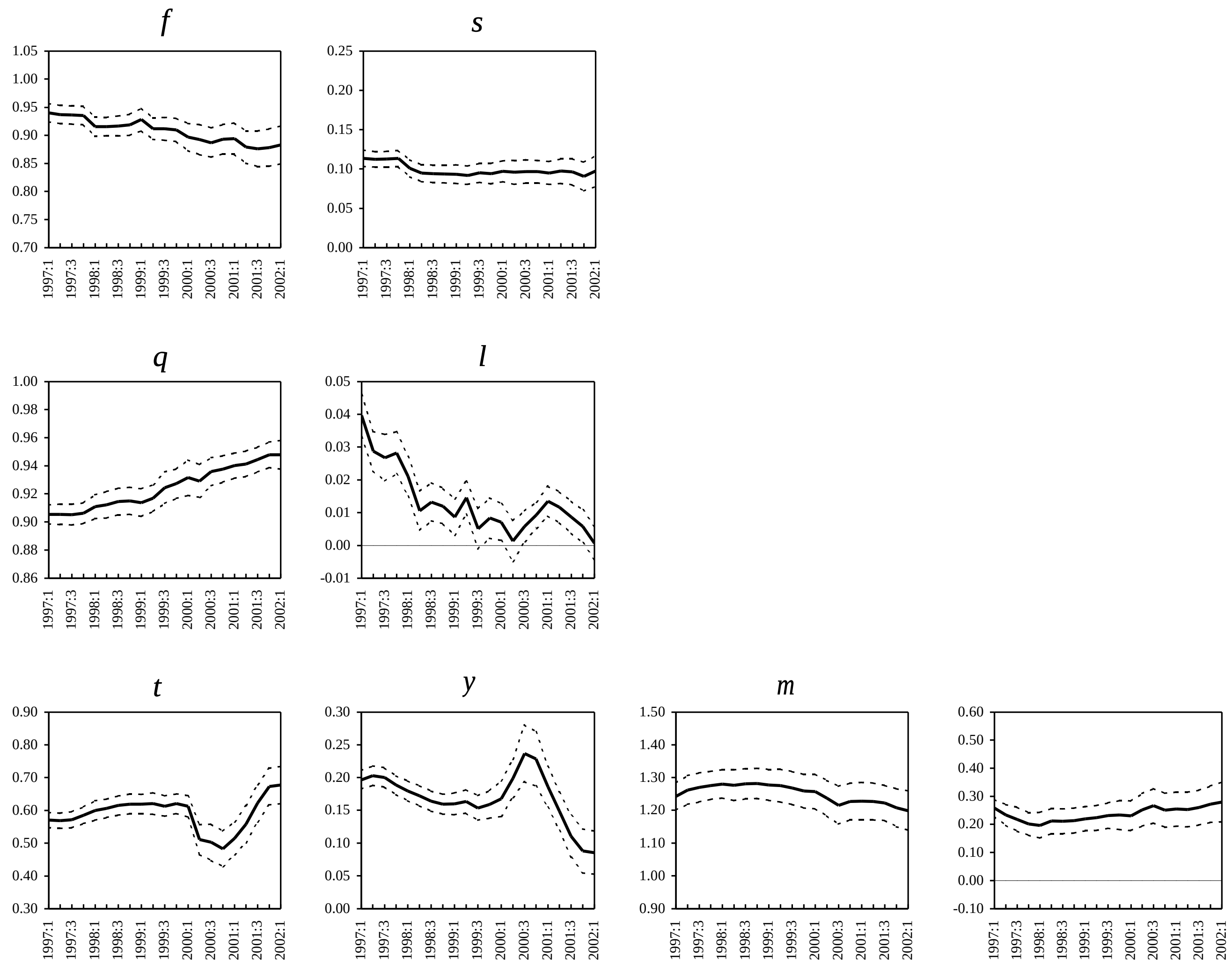
where $$p_t^* = m_t - a\,y_t^n + b\log\left(\frac{i_t^n}{1+i_t^n} + d\right) - g$$

(LM) $$Drm_t - Drm_t^n = t\,(Drm_{t-1} - Drm_{t-1}^n) - y\,(e_{t-1}) + h_t^{LM}\ , \qquad (9)$$

where $$e_t = rm_t - a\,y_t + b\log\left(\frac{i_t}{1+i_t} + d\right) - g$$

(MP) $$i_t = \frac{i_t^* + \sqrt{(i_t^*)^2 + w}}{2} + h_t^{MP}\ , \qquad (10)$$

where $$i_t^* = i_t^n + m\left[\frac{(Dp_t - p_t^*) + (Dp_{t-1} - p_{t-1}^*)}{2}\right] + n(y_t - y_t^n)$$



Notes: 1. This chart shows estimates of parameters from rolling regressions with the horizontal axis showing the end of sample for each regression. The starting point of regression is fixed at 1978:1.

2. Dotted lines show the interval estimates of ±2 standard errors.

3. Effects of the Y2K problem (2000/1Q) and the removal of blanket deposit insurance for time deposits, etc. (2002/1Q) are adjusted by dummy variables.

Active Money Paradigm [Case 3]

(AD-AMP) $$y_t - y_t^n = f(y_{t-1} - y_{t-1}^n) - s\left(i_{t-1} - E_{t-1}[Dp_t] - r_{t-1}^n\right) + x(Drm_{t-1} - Drm_{t-1}^n) + h_t^{AD} \quad (11)$$

(AS-AMP) $$Dp_t = q\,Dp_{t-1} + (1-q)Dp_{t-1}^* + l\,(p_{t-1}^* - p_{t-1}) + h_t^{AS}, \quad (15)$$

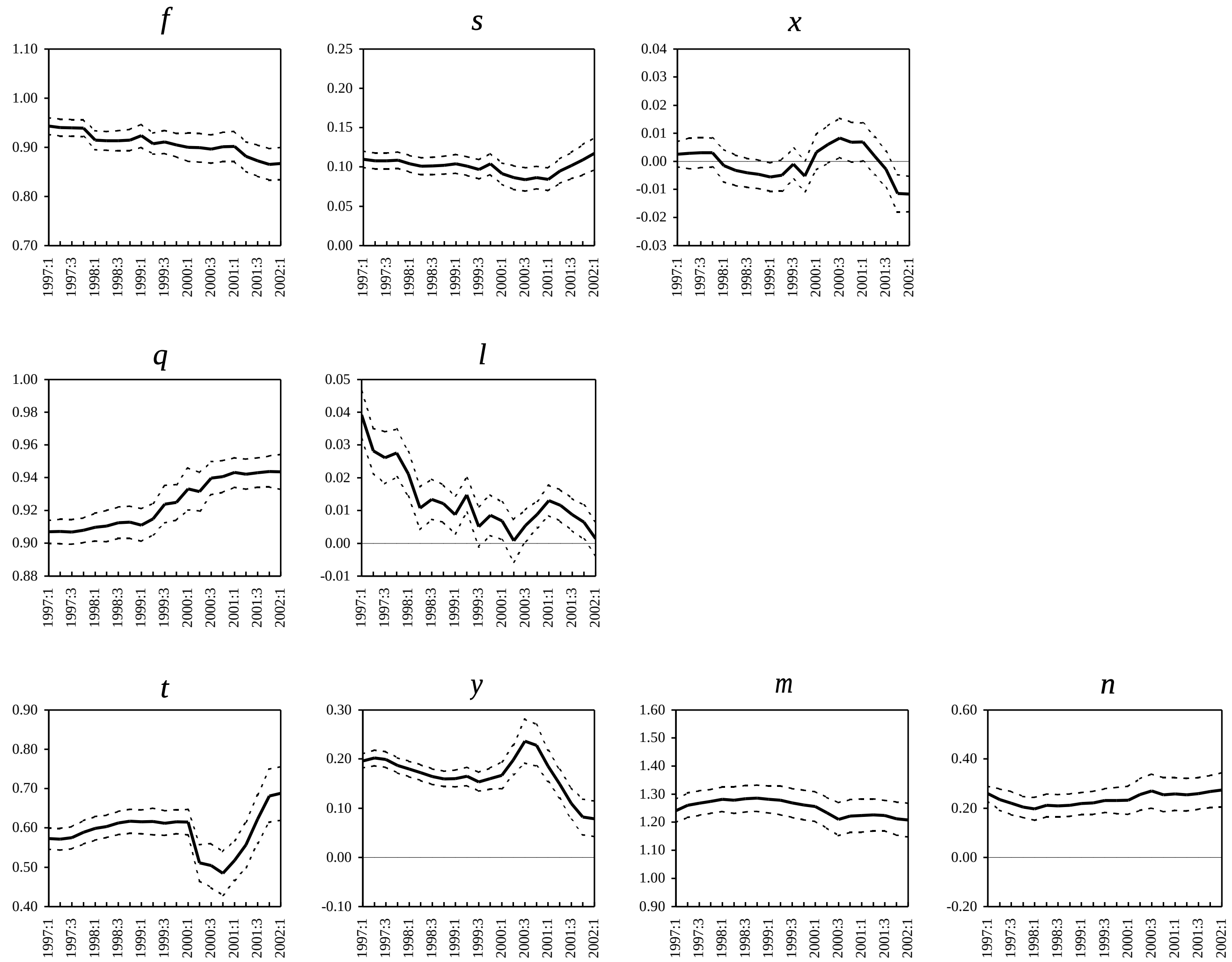
where $$p_t^* = m_t - a\,y_t^n + b\log\left(\frac{i_t^n}{1+i_t^n} + d\right) - g$$

(LM) $$Drm_t - Drm_t^n = t\,(Drm_{t-1} - Drm_{t-1}^n) - y\,(e_{t-1}) + h_t^{LM}, \quad (9)$$

where $$e_t = rm_t - a\,y_t + b\log\left(\frac{i_t}{1+i_t} + d\right) - g$$

(MP) $$i_t = \frac{i_t^* + \sqrt{(i_t^*)^2 + w}}{2} + h_t^{MP}, \quad (10)$$

where $$i_t^* = i_t^n + m\left[\frac{(Dp_t - p_t^*) + (Dp_{t-1} - p_{t-1}^*)}{2}\right] + n(y_t - y_t^n)$$



Notes: 1. This chart shows estimates of parameters from rolling regressions with the horizontal axis showing the end of sample for each regression. The starting point of regression is fixed at 1978:1.

2. Dotted lines show the interval estimates of ±2 standard errors.

3. Effects of the Y2K problem (2000/1Q) and the removal of blanket deposit insurance for time deposits, etc. (2002/1Q) are adjusted by dummy variables.