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Abstract

This paper analyzes the significance of the exchange rate channel, one of the transmission mechanisms of monetary policy. It is important to evaluate this channel for Japan because yen depreciation has been proposed as a policy to move the economy out of a liquidity trap. Our results suggest that, in the past, monetary expansion resulted in yen depreciation in the long- and short-run. However, there is no evidence to support the view that yen depreciation facilitated economic growth. Therefore, we conclude that use of the exchange rate as a mechanism to boost the real economy was, in our sample period at least, premature.

JEL classification: E520, F300
Keywords: Exchange rate channel, Japanese monetary policy

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1 Introduction

Since the financial bubble burst in the early 1990s, the Japanese economy has been in recession and its economic recovery remains fragile.[1] In order to facilitate economic recovery, a number of economic measures have been implemented by the government and the Bank of Japan (BOJ). Expansionary fiscal policy had been adopted and provided massive public works projects that were expected to induce a Keynesian stimulus to the economy. However, fiscal policy has become neutral in recent years because government deficits and debt have reached a high among industrialized countries.

With respect to monetary policy that will be the focus of our study, the BOJ started to reduce the official discount rate in 1991, which eventually led to short-term market rates reaching less than 1 percent in 1995. Furthermore, in February 1999 the BOJ introduced a zero-interest rate policy that targeted the short-term interest rate at zero percent, and a more aggressive expansionary monetary policy, quantitative easing, targeting the size of components of money (the BOJ's current account balance), was implemented in March 2001. An operational difference exists between these two policies, but short-term rates are expected to be around zero percent (BOJ 2001), and indeed they continue to be very close to the lower bound.

While narrow money has shown a significant increase particularly under the quantitative easing policy, there is no clear indication of a sustainable increase in price or output. In this regard, it is often said that Japan has been in a liquidity trap where no strong relationship exists between an increase in money supply and output.[2] According to textbooks (e.g., Mankiw 2003), a liquidity trap refers to a situation where the money demand curve becomes flat and therefore monetary policy is unable to affect the interest rate or output. In the Japanese case, nominal interest rates have already reached zero percent and thus are prevented from responding to monetary expansion because of their non-negativity constraint.[3]

In order to escape from a liquidity trap, many policy recommendations have been made including fiscal expansion, inflation targeting (Krugman 1998; Posen 1998), price level targeting (Svens-

[1] As of April 2005, while some signs of economic recovery can be seen in the export and manufacturing sectors due partly to strong economic growth overseas, growth in industrial production has stayed steady (Bank of Japan, 2005)

[2] Some economists (e.g., Hondroyiannis, Swamy, and Tavlas, 2002) argue against Japan being categorized as caught in a liquidity trap, hence their conclusion that money expansion is useful for economic recovery.

[3] Krugman (1998) argues that, in this circumstance, the health of the financial institutions is not an important factor when studying the effectiveness of monetary policy. According to his argument, the fact that nominal interest rates have reached zero percent is the main problem facing the BOJ. Alternatively, there is a view that the perceived weak relationship between narrow money and output has been caused by the slow implementation of structural reform (or *microeconomic reform*), especially in the financial sector. In particular, unresolved non-performing loans still appear to prevent most Japanese banks from functioning properly as financial intermediaries (e.g., Morsink and Bayoumi 2000).

son 2001), aggressive monetary expansion (Krugman 1998; Meltzer 2001; Clouse *et al* 2003), a reduction in the long-term interest rates (Meltzer 2001; Clouse *et al* 2003), exchange rate depreciation (McCallum 2000; Orphanides and Wieland 2001; Svensson 2001), and so on.[4] Obviously, these policies likely complement each other. For example, a reduction in long-term interest rates and yen deprecation may result from monetary expansion, and monetary expansion itself can be implemented in the context of an inflation targeting policy.

With respect to the exchange rate channel, several proposals exist. However, while agreeing that yen depreciation is required to stabilize inflation and output, these proposals are rather different on an operational level. For example, imposing a lower bound for interest rates, Orphanides and Wieland (2000) analyzed the exchange rate channel based on the calibrated open economy model where the quantity of reserve money has a direct effect on the exchange rate. Therefore, yen depreciation may be regarded as the outcome of monetary expansion. McCallum (2000) proposes a more direct approach to bring about yen depreciation. Namely, the BOJ can affect the exchange rate by purchasing foreign exchange in open market operations (portfolio balance effects). Finally, Svensson (2001) proposed a so-called foolproof way. His proposal is based on a combination of several measures consisting of a target price level, yen devaluation, and a temporary exchange rate peg.

Against this background, this paper assesses the significance of the exchange rate channel in the past. More specifically, we examine whether or not yen depreciation was caused by monetary policy and, if so, whether yen depreciation helped increase output. It is generally viewed that an expansion in reserve money through an increase in the BOJ's current account balance did not result in significant yen depreciation nor an increase in output. Using actual data, a partial analysis has already been conducted on the exchange rate channel using Japanese data (e.g., Bahmani-Oskooee 2004; Fujii 2004). They examined the effect of the exchange rate on the trade balance and prices respectively, and came to the conclusion that the exchange rate channel was insignificant during the recent recessionary period. Our study differs from these studies since it analyzes the whole exchange rate channel starting with money representing the BOJ's stance on monetary policy, moving on to the exchange rate and finally to output.[5] Therefore, we will look into the link between money and the exchange rate which has not yet been analyzed in previous research.

The subsequent part of this paper comprises 4 sections. Section 2 explains the theoretical model following the monetary approach to exchange rate determination. This economic theory links the exchange rate with money supply and output. Section 3 studies the time-series properties of the data, and analyzes the stability of the exchange rate model. Furthermore, this section investigates

[4]See Svensson (2004) for a review of literature related to the Japanese recession and monetary policy.

[5]However, the relationship between money and prices is not examined in this paper since its validity has already been confirmed by previous studies.

whether or not the exchange rate (output) responds to changes in money (exchange rate). Finally, we conclude with a summary and discussion of policy implications based on our empirical results. In short, we conclude that, in contrast to general expectations, the exchange rate has indeed been responding to Japanese monetary policies, and expansionary policies are particularly effective in inducing yen depreciation. However, we find that exchange rate movements were not significant enough to turn around the economy on a sustainable basis.

2 Theoretical Background

While many exchange rate theories exist, this paper uses the standard theory based on the monetary approach to exchange rate determination (MAER). This theory is based on the purchasing power parity (PPP), the Cagen-type money demand functions, and the uncovered interest parity (UIP), and asserts that exchange rate dynamics can be explained by the money and output of domestic and partner countries.[6]

$$s_t = m_t - m_t^* - \theta(y_t - y_t^*) + \eta(E_t s_{t+1} - s_t) \tag{1}$$

Notably, the exchange rate brings about an equi-proportional effect on money.

Solving equation (1) forwardly, we can obtain the following dynamic exchange rate equation.

$$s_t = \frac{1}{1+\eta} \sum_{s=t}^{\infty} \left(\frac{\eta}{1+\eta} \right)^{s-t} E_t z_s + \lim_{T \to \infty} \left(\frac{\eta}{1+\eta} \right)^{T} E_t s_{t+T} \tag{2}$$

where $z_t = m_t - m_t^* - \theta(y_t - y_t^*)$. Consider a non-bubble situation where the second term in RHS is equal to zero:

$$\lim_{T \to \infty} \left(\frac{\eta}{1+\eta} \right)^{T} E_t s_{t+T} = 0 \tag{3}$$

Furthermore, let us introduce persistence in z_t by, for simplicity's sake, assuming the same adjustment speed (ρ) for all variables in z_t.

$$z_t = \rho z_{t-1} + \varepsilon_t \tag{4}$$

where $0 \leq \rho \leq 1$, and ε_t is white noise, and the persistence in the indicators is expressed as an auto-regression (AR(1)) process. Obviously, when there is no persistence ($\rho = 0$), z_t follows the

[6] This exchange rate equation is obtained assuming the same parameters for interest rates across countries. This assumption seems appropriate given that interest rate semi-elasticity is around 0.04 and 0.02-0.8 using U.S. and Japanese quarterly data respectively (Ball 2001 and Nakashima and Saito 2002). However, even when interest rate elasticity differs across countries, our empirical analysis is still valid as long as the interest rate differential is stationary.

white noise process ($z_t = \varepsilon_t$). When the persistence level increases ($\rho \to 1$) and $\rho = 1$, z_t is said to possess the unit root. Using equations (2), (3), and (4), the exchange rate equation becomes:

$$s_t = \frac{1}{1+\eta}\sum_{s=t}^{\infty}\left(\frac{\eta\rho}{1+\eta}\right)^{s-t} z_t = \frac{1}{1+\eta-\eta\rho} z_t = \frac{1}{1+\eta-\eta\rho}[m_t - m_t^* - \theta(y_t - y_t^*)] \tag{5}$$

When $\rho = 1$, equation (5) becomes the standard MAER. In contrast, when $\rho \neq 1$, the sensitivity of the exchange rate to changes in the explanatory variables differs from the theoretical value predicted by the standard monetary approach. It should be noted that this exchange rate equation (5) does not include the interest rate and so may offer the convenient possibility of avoiding the nonlinearity issue in the estimation caused by the nonnegativity constraint on interest rates.[7]

Previous research generally supports the MAER by finding one or more co-integrating relationships in the unrestricted version of the MAER (e.g., MacDonald and Taylor 1991) although there is some evidence against the validity of each component of the model; namely, PPP, money demand functions, and UIP.[8] For this reason, the subsequent part of this paper also relaxes the parameter restrictions.

3 Empirical Analysis

3.1 Time-Series Properties of the Data

This section describes the data used in this paper. Our dataset includes the exchange rate, money, and output, which are quarterly and cover the period 1970Q1-2003Q1. The beginning of our sample period is chosen in order to exclude as many observations as possible during the fixed exchange rate period.[9] The exchange rate is expressed in terms of a single U.S. dollar, and thus yen deprecation is indicated by an increase in s_t in equation (5). The exchange rate data are plotted in Figure 1, which shows that the yen has an upward (depreciation) trend since the mid-1990s, and thus it appears that the recent monetary increase has been associated with yen depreciation during this period. Money is represented by reserve money that captures the stance of the BOJ monetary policy even when nominal interest rates are zero percent. The output is approximated by GDP,

[7] In addition, the statistical method proposed by Hansen (1991) provides critical values for the model with up to four explanatory variables.

[8] A half-life of deviations from PPP is very slow and lasts three to five years (Rogoff 1996). Similarly, the standard money demand function holds for Japan only until 1990 (Nagayasu 2003) and UIP does not hold because of the existence of a time-varying risk premium and the irrationality of investors (MacDonald and Torrance 1990).

[9] While some fixed exchange rate data (i.e., pre-1973Q2 data) are included here, the results from Hansen's tests, which require trimming at the beginning and end of the observations, produce results relevant to the flexible exchange rate period. In addition, there is no significant difference in the results even when only post-1973Q2 data are analyzed.

and the real output is obtained using the consumer price index (CPI).[10] In addition, industrial production is employed to proxy the output. All data are obtained from the IMF's *International Financial Statistics* except the money indicators that are taken from the databases of the BOJ and the Federal Reserve System. In the subsequent study, Model 1 refers to one including the GDP, while Model 2 is based on the industrial production.

[Figure 1]

3.2 Stability Analysis

This paper examines the stability of equation (5) using two methods: Hansen (1991) and Hansen and Johansen (1999) which do not require a priori information on the timing of the breaks. Hansen's instability tests can be viewed as one form of co-integration test, and provide evidence for the existence of co-integration in the presence of stability in the model. Hansen has proposed three statistics; namely Lc, $MeanF$, and $SupF$ statistics, in order to examine the null hypothesis of stable coefficients against the different alternatives–some form of instability in the model.[11] He argues that these three tests have similar power, but it seems most suitable to use the $SupF$ test when analyzing sudden shifts in the data. Furthermore, when parameter changes are relatively slow during the sample, the Lc statistic is probably the best option. This paper uses all three tests since no exact information is available about the nature of the shifts in the data.[12]

The results from Hansen's tests are reported in Table 1. We consider several exchange rate specifications that are estimated using the Fully-Modified OLS method. As discussed in footnote 9, calculating Hansen's statistics requires data truncation, which leads us to focus on the sample from $0.15T$ to $0.85T$ where T is the total number of our observations. According to our results, there is evidence to support Model 1 that is based on reserve money and GDP. All the significant parameters in Model 1 are correctly signed, and notably the coefficient for Japanese reserve money is positive and is significant. This positive sign for money indicates that monetary expansion has resulted in yen depreciation in the past. The relationship between the reserve money and exchange rate movements has not been directly explored in previous empirical research on the exchange rate

[10]The CPI, rather than the GDP deflator, is chosen to represent the price in our study because it is the main price indicator used by the BOJ to monitor price movements and offers more up-to-date data. Walsh (2003) also supports use of the CPI for the analysis of the exchange rate channel in Japan. One should however be cautious about the results reported here because they may be sensitive to the choice of price indices as they have behaved rather differently in Japan.

[11]Thus, the word, "stability," is often used as a synonym for "co-integration" in this paper.

[12]For estimation, the Bartlett kernel estimator is used to obtain a consistent estimate for the covariance matrix, and pre-whitened data, following Andrews and Monahan's method (1992), are used to deal with autocorrelated and heteroskedastic errors.

channel. In this regard, our finding of its positive influence on the exchange rate deserves attention and provides some justification for these policies.

Furthermore, the parameter size for the domestic money is well below the theoretical value of unity, and seems to be consistent with Orphanides and Wieland (2000) who based on simulation exercises indicate that substantial monetary easing is necessary to bring about yen depreciation sufficient for stabilizing inflation and output. Furthermore, the parameter size suggests that $\eta \neq 0$ and $\rho \neq 1$ in equation (5), the latter indicating significant persistence in the data.

In addition, all three Hansen statistics are less than the critical values, thereby providing evidence of parameter stability in this model. In this regard, we conclude that there is a stable relationship between exchange rate, reserve money, and output.

The result of Model 1 is generally confirmed using different proxies for output, the industrial production (Model 2). One notable point in these models is that the coefficients for U.S. output are negative in all cases in contrast to economic theory, and this parameter is significant for Model 2. This result may reflect Japan's heavy reliance on the U.S. whereby a strong economy in the U.S. increases the Japanese current account balance which in turn induces yen appreciation in order to restore economic equilibrium.

[Table 1]

The sequence of *SupF* over time is shown in Figures 2 to 3. These figures show the statistics for Models 1 to 2, and present our previous results in a different form and are useful to pinpoint the date of breaks if indeed such exist. According to the figures, *SupF* statistics are less than the critical values for Models 1 to 2 indicating the stability of the exchange rate equation.

[Figures 2 and 3]

The stability of Models 1 and 2 is also confirmed by Hansen and Johansen's approach that can be viewed as an extension of the multivariate co-integration method (Johansen 1991). In order to carry out the analysis, Johansen's test based on the VAR is, first of all, implemented. This test allows us to examine the number of co-integration based on the maximum likelihood method. Assuming that x_t is an $m \times 1$ vector comprising $I(1)$ variables and using the first difference of x_t ($\Delta x_t = x_t - x_{t-1}$) that is stationary, the error correction model can be expressed as:

$$\Delta x_t = \Pi x_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta x_{t-i} + \varepsilon_t \tag{6}$$

where $t = 1, 2, ..., T$, $E(\varepsilon_t) = 0$, and $E(\varepsilon_t \varepsilon_t') = \Sigma$. Furthermore, $\Pi = \sum_{i=1}^{p} \Pi_i - I$, $\Gamma_i = -\sum_{j=i+1}^{p} \Pi_j$, and $\Gamma = I - \sum_{i=1}^{p} \Gamma_i$. Johansen proposes the null hypothesis, $H_0 : \Pi = \alpha\beta'$, where α and β are both $m \times r$ matrices, in order to analyze the number of co-integration in the

system. The vector β is called the co-integrating vector and α is an adjustment vector that measures the speed of convergence to the steady-state. The rank (r) of Π corresponds to the number of co-integration. In the presence of co-integration (i.e., $1 \leq r < m$), $\beta' x_t$ is stationary.

Our analysis is based on $x_t = [s_t, m_t, m_t^*, y_t, y_t^*, 1]'$ and $p = 2$ for Models 1 and 2. This lag length is suggested by all information criteria such as final prediction error (FPE), and Akaiki, Schwarz, and Hannan-Quinn information criteria (Table 2). Based on this VAR, the number of co-integration is analyzed using the trace and likelihood ratio statistics proposed by Johansen. Both statistics suggest that there is one linear combination that is stationary in the system for both models (Table 3). The existence of co-integration in the Johansen test is consistent with that of the stability in the exchange rate equation from Hansen's tests.

[Tables 2 and 3]

Furthermore, based on the Hansen and Johansen method, we have checked the constancy of the eigenvalues used to calculate the trace and likelihood ratio statistics. This test statistic is called the τ statistic which is obtained by recursive estimation, and examines the null hypothesis of constant eigenvalues. The constancy of the eigenvalues can be translated into the reliability of the trace and likelihood ratio tests. Figures 4 and 5 show that τ statistics are less than the five percent critical value over time, and thus confirm a stable co-integrating vector in our exchange rate equation.

[Figures 4 and 5]

3.3 Effects of an Exchange Rate Shock on Output

Given some statistical evidence for the money-exchange rate relationship, we turn our attention to the exchange rate-output relationship in order to complete our analysis of the exchange rate channel. Most of this analysis is a re-interpretation of our previous results from the Fully-Modified OLS and co-integration analysis.

In the previous section, we obtained one stable or long-run relationship which was assumed to correspond to the exchange rate equation. In order to analyze the exchange rate-output relationship, this assumption is examined in this section using the restricted error correction model. This model can be obtained by imposing parameter restrictions on equation (6). Thus, the restricted β will yield $\widehat{\Pi} = \alpha\widehat{\beta}$ in (6), where the hat indicates restricted parameters that are consistent with our FM-OLS estimates. In this study, parameter restrictions are imposed on the vector β except the constant term that is allowed to differ from our previous finding. Normalizing the parameter for

the exchange rate, the co-integrating and adjustment vectors for Models 1 and 2 are shown below:

$$\widehat{\Pi} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \\ \alpha_4 \\ \alpha_5 \end{bmatrix} [\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6] = \begin{bmatrix} -0.201 \\ (0.056) \\ 0.391 \\ (0.185) \\ 0.098 \\ (0.097) \\ -0.003 \\ (0.015) \\ 0.022 \\ (0.023) \end{bmatrix} [1.000, -0.212, 0.752, 0.801, 0.832, -17.719] \quad (7)$$

$$\widehat{\Pi} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \\ \alpha_4 \\ \alpha_5 \end{bmatrix} [\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6] = \begin{bmatrix} -0.118 \\ (0.042) \\ 0.229 \\ (0.143) \\ -0.066 \\ (0.080) \\ -0.013 \\ (0.013) \\ 0.004 \\ (0.011) \end{bmatrix} [1.000, -0.195, 1.068, 0.609, 0.660, -14.547] \quad (8)$$

where numbers in parentheses indicate standard errors, and the number of parameters (e.g., α_1 and β_1) corresponds to the order of variables in x_t. These parameter restrictions are accepted by the data using the likelihood ratio test ($\chi^2(4) = 5.206$ and $\chi^2(4) = 7.829$ for Models 1 and 2 respectively). The large negative value of α_1 provides strong evidence of feedback effects to the exchange rate, justifies our choice of parameter normalization, and provides evidence that the co-integrating vector is for the exchange rate function.

This finding in turn implies the absence of long-run causality from the exchange rate to output. Therefore, one could conclude that yen depreciation did not facilitate sustainable economic growth. This conclusion is also supported by the other exchange rate model using the industrial production data that are presumably more sensitive to exchange rate dynamics than the GDP because a higher proportion of industrial companies are engaged in international trade.

The absence of a second half of the exchange rate channel is consistent with previous studies. For example, Miyao (2003) provides evidence of an insignificant relationship between the exchange rate and the trade balance since the mid-1980s. This insignificance appears to arise from the non-sensitivity of exports to exchange rate depreciation (Bahmani-Oskooee and Goswami 2004). Probably, as summarized in MacDonald (2002), one should not expect a permanent relationship between the exchange rate and output. His literature review on exchange rates and economic growth shows that volatility, one feature of a flexible exchange rate, more likely affects output

through trade and investment channels. Indeed, economic growth theory suggests that the exchange rate *per se* is not a determinant of economic growth although exchange rate misalignments for example could be an important factor.

Finally, the presence of one co-integration suggests not only the absence of the above-mentioned long-run relationship between the exchange rate and output. It also implies that monetary expansion did not result in increased output on a permanent basis. This conclusion is confirmation of our overall findings in this paper; the exchange rate channel has functioned during our sample period, but only as far as the exchange rate.[13]

3.4 The Short-term Dynamics and Asymmetric Behavior of Exchange Rates

So far, our analysis has focused mainly on the permanent relationship between Japanese reserve money, the exchange rate, and output. This section looks into their short-term relationship, and furthermore attempts to find whether any asymmetric relationship exists among them. This is because the exchange rate and output may react differently depending for instance on the type of monetary policy.

For this purpose, the Markov Switching (MS)-Vector Error Correction Model (VECM) will be employed.[14] In particular, we shall use the MSIH(k)-VECM(p), where $k = 2$ and $p = 1$ The I and H after MS stand for Intercept and Heteroskedasticity, and thus indicate that the model is an extension of MS allowing the intercept and variability of the disturbances to be dependent on the regime that is governed by a Markov chain. The k and p indicate the number of regimes and lag order. Our choice of the lag length ($p = 1$) is consistent with one for the VAR in levels.

Furthermore, we consider the following two types of regimes in two different models. In the first model, we examine asymmetry triggered by an increase or decline in Japanese reserve money. Regime 1 thus refers to an economic situation with negative growth in the Japanese money reserve, while with Regime 2 there is a positive increase in Japanese reserve money. In the second model, we consider any asymmetric behavior of the exchange rate and output before or after 1995. In this case, Regime 1 refers to a period up to the end of 1994, and Regime 2 from 1995 onwards. Since nominal short-term interest rates reached almost a zero lower bound in 1995, any effects of the recent monetary policy should again be captured by Regime 2.

[13] As suggested by the referee, we have also examined the relationship between Japanese reserve money and the real effective exchange, and between between the real effective rate and output. Use of the real effective rate is encouraged because there are a number of trading countries (other than the U.S.) and monetary expansion would stimulate output through real depreciation. The results from the Johansen method are consistent with ones reported in the main text using the bilateral/nominal exchange rate. In other words, a co-integrating relationship exists between reserve money and the real effective rate, but such a relationship is absent between reserve money and output.

[14] The model is estimated by the maximum likelihood method. See Krolzig (1997) for details of the model and estimation method.

Finally, using the notation used in equation (6), the composition of endogenous variables x is U.S. output and reserve money, Japanese output, reserve money, and exchange rate (in that order). The GDP represents output in this subsection.[15] Thus, our model assumes that a shock to Japanese money will simultaneously affect the exchange rate, which I believe is reasonable given the low frequency of the data and the high sensitivity of the exchange rate to reserve money. Then, the shock will be passed on to the Japanese output and finally on to the U.S. money and output. The error correction term (ECM) based on (7) is used here.

Now, let us discuss our results from the first model where regimes are triggered by a negative or positive change in Japanese reserve money. The estimates of this model are presented in Table 4. The asymmetry test provides evidence against linearity in our data. Furthermore, the orthogonalized impulse response analysis is conducted using this model that visualizes important information contained in Table 4. Figure 6 provides the probabilities of Regimes 1 and 2, and in Figure 7, only the responses of the exchange rate and Japanese output to Japanese reserve money are shown for presentation purposes. This figure provides very interesting results; in particular, under Regime 2 that is of interest to us, we can observe that the shock to Japanese reserve money causes yen depreciation, and some very minor effects on the Japanese GDP. This seems to confirm our finding in the previous sub-section that recent Japanese monetary policy was effective in affecting exchange rates but not its output.

[Table 4 and Figures 6, 7]

How about when the regimes would be expected to be divided around 1995? Table 5 summarizes estimates of the MSIH(2)-VECM(1) model, and the probabilities for the regimes are plotted in Figure 8. Figure 9 shows the behaviors of the Japanese GDP and the exchange rate in response to a shock to the Japanese reserve money. The result is quite similar to that obtained from the first model. We confirm some degree of yen depreciation since 1995 but the extent to which it is affected by reserve money is limited. What is more limited is Japanese output that hardly reacts to monetary policy. Our results also suggest that monetary easing was not aggressive enough if the exchange rate channel is one that can vitalize the Japanese economy. Therefore, they are in line with Orphanides and Wieland (2000) who argue that with zero interest rates, very aggressive monetary easing is needed to obtain clear signs of economic recovery.

[Table 5 and Figure 8, 9]

[15] A more or less identical result is obtained when industrial production is used in place of the GDP.

4 Summary and Discussion

In order to assess the effectiveness of Japanese monetary policy, this paper empirically analyzes the exchange rate channel, one of the transmission mechanisms of monetary policy. To this end, first, we have studied the effects of monetary expansion on the exchange rate and then of the exchange rate on output. It is important to visit this topic since yen devaluation has been proposed as one effective way to remove Japan from the liquidity trap.

The overall conclusion of this paper is that the effects of monetary policy have reached as far as the exchange rate, but that the exchange rate channel was not functioning sufficiently to affect output. This finding based on actual data is very important when examining the exchange rate channel since previous study did not consider a link between the exchange rate and money. Furthermore, our finding is in sharp contrast to the conventional belief that monetary expansion does not affect the exchange rate at all. While our conclusion may pose a question with respect to the use of yen deprecation as a way to escape from the liquidity trap, it is hardly surprising that strong evidence is not obtained that the exchange rate has significantly affected Japanese output in the past. Indeed, literature on economic growth theory suggests inclusion of exchange rate misalignment, but not exchange rates per se, as a determinant for economic growth. Furthermore, it is consistent with the simulation results of Orphanides and Wieland (2000).

While not discussed in this paper, foreign exchange intervention has often been argued as a way to bring about yen deprecation. However, this policy is even less promising than quantitative easing. This is because, as many researchers (e.g., Nagayasu 2004) have demonstrated, it requires concerted efforts among monetary authorities in different countries to obtain the expected result, and such cooperation among central banks requires an international political commitment that would unlikely be sustainable on a permanent basis. Furthermore, if there were the international political will for concerted intervention, it would likely have only temporary effects and thus cannot be considered a long-run solution for bringing about sustainable economic growth. In this regard, it is very doubtful if intervention could be considered a promising policy for inducing useful yen depreciation.

In short, based on previous experiences in the Japanese context, the results of this paper cast some doubt on the possibility of exchange rate depreciation being thought of as a direct measure to escape from recession.

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Table 1: **Hansen's Stability Tests Applied to Exchange Rate Equations**

	Model 1	Model 2
m	0.212 [0.092]	0.195 [0.091]
$m*$	-0.752 [0.262]	-1.068 [0.254]
y	-0.801 [0.387]	-0.609 [0.262]
$y*$	-0.832 [0.480]	-0.660 [0.268]
$Const$	17.761 [1.635]	14.549 [0.933]
Lc	0.619 (0.200)	0.556 (0.200)
$MeanF$	5.845 (0.200)	4.502 (0.200)
$SupF$	15.167 (0.185)	9.341 (0.200)
Automatic bandwidth	1.630	1.163

Note: Full sample period. Model 1 is based on reserve money and GDP, and Model 2 on reserve money and industrial production. The reported estimates are based on the fully-modified ordinary least squares. The parameter instability test statistics proposed by Hansen (1991) are Lc, $MeanF$, and $SupF$. The numbers in brackets indicate standard errors while those in parentheses are p-values. Following Hansen (1991), p values greater than 0.200 are indicated as 0.200.

Table 2: **The Lag Order Selection Criteria for the VAR**

Lag	FPE	AIC	SC	HQ
Model 1				
0	1.01E-08	-4.225	-4.111	-4.179
1	4.13E-14	-16.628	-15.942	-16.349
2	*1.98E-14*	*-17.364*	*-16.106*	*-16.853*
3	2.35E-14	-17.200	-15.371	-16.457
4	2.41E-14	-17.184	-14.784	-16.209
5	2.45E-14	-17.183	-14.210	-15.975
6	2.66E-14	-17.123	-13.579	-15.683
7	3.36E-14	-16.924	-12.808	-15.252
8	3.66E-14	-16.881	-12.194	-14.977
9	3.67E-14	-16.937	-11.679	-14.801
10	3.69E-14	-17.006	-11.176	-14.638
Model 2				
0	1.01E-08	-4.225	-4.111	-4.179
1	4.13E-14	-16.628	-15.942	-16.349
2	*1.98E-14*	*-17.364*	*-16.106*	*-16.853*
3	2.35E-14	-17.200	-15.371	-16.457
4	2.41E-14	-17.184	-14.784	-16.209
5	2.45E-14	-17.183	-14.210	-15.975
6	2.66E-14	-17.123	-13.579	-15.683
7	3.36E-14	-16.924	-12.808	-15.252
8	3.66E-14	-16.881	-12.194	-14.977
9	3.67E-14	-16.937	-11.679	-14.801
10	3.69E-14	-17.006	-11.176	-14.638

Note: Full sample period. The terms, FPE, AIC, SC, and HQ stand for the Final Prediction Error, and Akaiki, Schwarz, and Hannan-Quinn information criteria. See Lütkepohl (1993) for details about these criteria for selecting an appropriate lag length. The minimum statistics for each criterion are expressed in italics.

Table 3: **Johansen's Test**

H_0	Trace statistic	5 percent critical value	Max-eigen statistic	5 percent critical value
Model 1				
None	*83.019*	68.520	*41.819*	33.460
At most 1	41.200	47.210	23.543	27.070
At most 2	17.658	29.680	11.100	20.970
At most 3	6.557	15.410	6.121	24.070
At most 4	0.436	3.760	0.436	3.760
Model 2				
None	*76.206*	68.520	*39.666*	33.460
At most 1	36.541	47.210	21.850	27.070
At most 2	14.691	29.680	9.004	20.970
At most 3	5.687	15.410	4.544	24.070
At most 4	1.143	3.760	1.143	3.760

Note: Full sample period. The critical values are obtained from Osterwald-Lenum (1992), and statistics greater than the critical values are written in italics. The lag order is 2 for these models based on the information criteria in Table 1. The constant term is included in the co-integrating vector.

Table 4: **The MSIH(2)-VAR(1)**

	Δy_t^*	Δm_t^*	Δy_t	Δm_t	Δs_t
Const (Regime 1)	-0.003 [0.005]	0.003 [0.082]	-0.005 [0.005]	-0.134 [0.096]	0.012 [0.043]
Const (Regime 2)	-0.001 [0.004]	0.023 [0.079]	-0.005 [0.005]	-0.064 [0.118]	0.010 [0.035]
Δy_t^*	0.316 [0.079]	-0.434 [0.753]	0.421 [0.097]	-1.805 [0.856]	-0.388 [0.472]
Δm_t^*	-0.006 [0.006]	-0.511 [0.077]	0.035 [0.006]	0.080 [0.090]	0.021 [0.045]
Δy_t	-0.013 [0.058]	1.038 [0.546]	-0.004 [0.069]	1.260 [0.637]	0.021 [0.336]
Δm_t	-0.005 [0.003]	0.006 [0.056]	-0.021 [0.004]	-0.118 [0.068]	-0.009 [0.029]
Δs_t	-0.025 [0.013]	0.156 [0.146]	0.009 [0.015]	0.279 [0.165]	0.218 [0.090]
ECM_{t-1}	0.000 [0.000]	0.000 [0.006]	0.001 [0.000]	0.011 [0.006]	-0.001 [0.003]
SE (Regime 1)	0.010	0.079	0.014	0.089	0.050
SE (Regime 2)	0.004	0.182	0.008	0.380	0.045
Nonlinearity(p-prob)	157.081 (0.000)				

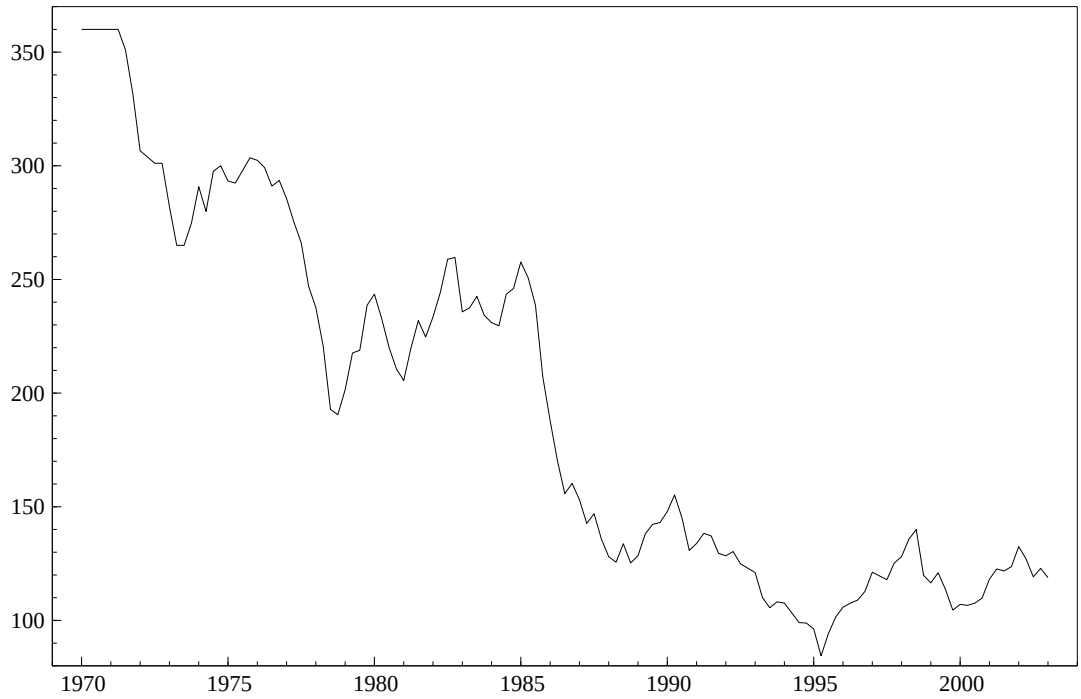
Note: Full sample period. The *Const* is the constant term, and *SE* stands for the standard error. The statistics in brackets are also standard errors. The nonlinearity test is based on the likelihood ratio test (see Krolzig (1997) for details), and is distributed as $\chi^2(20)$.

Table 5: **The MSIH(2)-VAR(1)**

	Δy_t^*	Δm_t^*	Δy_t	Δm_t	Δs_t
Const (Regime 1)	-0.009 [0.006]	-0.002 [0.085]	0.013 [0.009]	-0.127 [0.106]	-0.005 [0.042]
Const (Regime 2)	-0.007 [0.005]	0.002 [0.079]	0.004 [0.008]	-0.073 [0.113]	0.014 [0.040]
Δy_t^*	0.222 [0.091]	-0.643 [0.850]	0.143 [0.119]	-1.966 [0.900]	-0.334 [0.443]
Δm_t^*	-0.001 [0.007]	-0.445 [0.094]	0.039 [0.011]	0.025 [0.103]	0.003 [0.046]
Δy_t	0.022 [0.058]	0.846 [0.631]	-0.176 [0.082]	0.947 [0.701]	0.217 [0.334]
Δm_t	0.001 [0.004]	-0.040 [0.066]	-0.020 [0.007]	-0.041 [0.090]	-0.024 [0.033]
Δs_t	-0.022 [0.014]	0.060 [0.170]	-0.021 [0.022]	0.410 [0.221]	0.245 [0.088]
ECM_{t-1}	0.001 [0.000]	0.001 [0.006]	-0.000 [0.001]	0.011 [0.007]	-0.003 [0.003]
SE (Regime 1)	0.010	0.088	0.013	0.092	0.047
SE (Regime 2)	0.006	0.132	0.012	0.308	0.056
Nonlinearity(p-prob)	133.375 (0.000)				

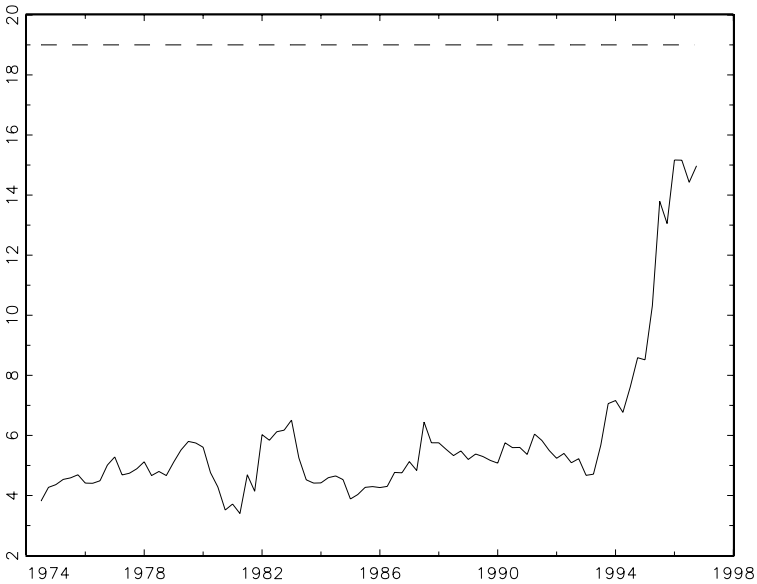
Note: Full sample period. The *Const* is the constant term, and *SE* stands for the standard error. The statistics in brackets are also standard errors. The nonlinearity test is based on the likelihood ratio test (see Krolzig (1997) for details), and is distributed as $\chi^2(20)$.

Figure 1: **The Yen-U.S. Dollar Exchange Rate**



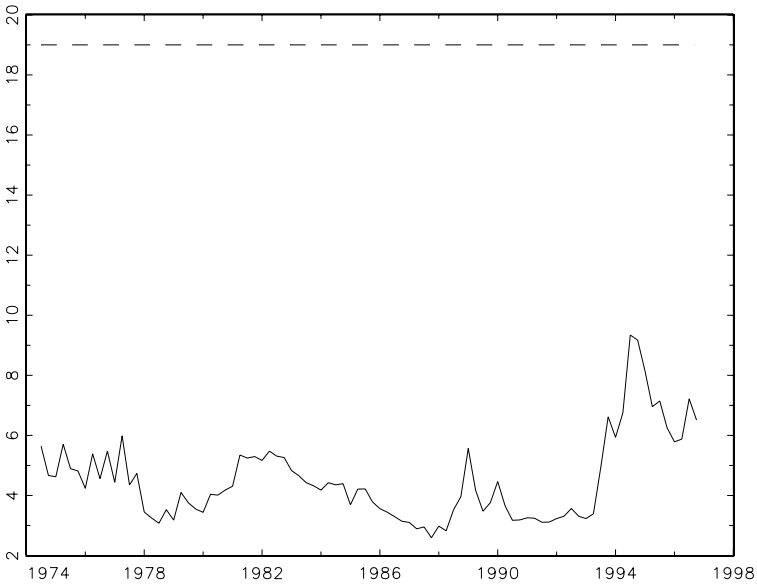
Note: Y axis measured in yen.

Figure 2: **Hansen's Parameter Instability Test (Model 1)**



Note: The definition of Model 1 is provided in the main text and Table 1. Figure 2 plots the sequence of statistics for the Hansen test, and a critical value (a dot line) for $SupF$ is provided by Hansen (1992a). The statistics less this critical value indicates parameter stability.

Figure 3: **Hansen's Parameter Instability Test (Model 2)**

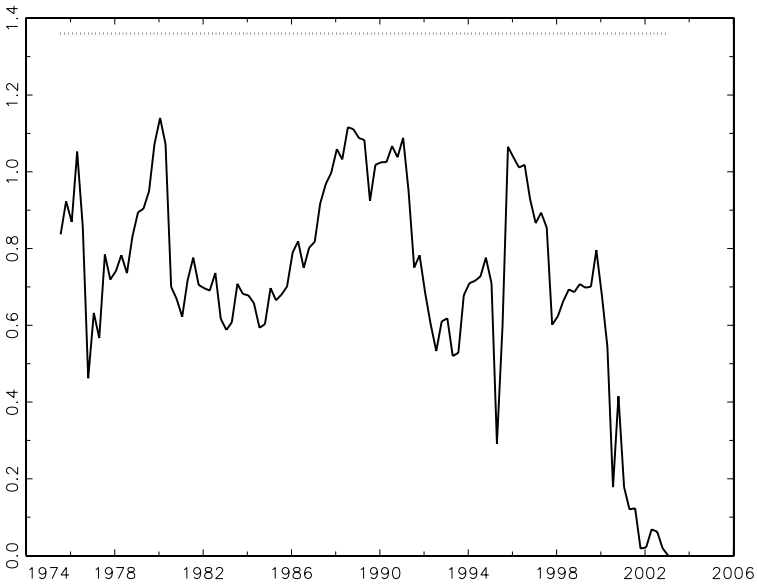


Note: The definition of Model 2 is provided in the main text and Table 1. Figure 3 plots the sequence of statistics for the Hansen test, and a critical value (a dot line) for $SupF$ is provided by Hansen (1992a). The statistics less this critical value indicates parameter stability.

Figure 4: **Hansen and Johansen's Parameter Instability Test (Model 1)**

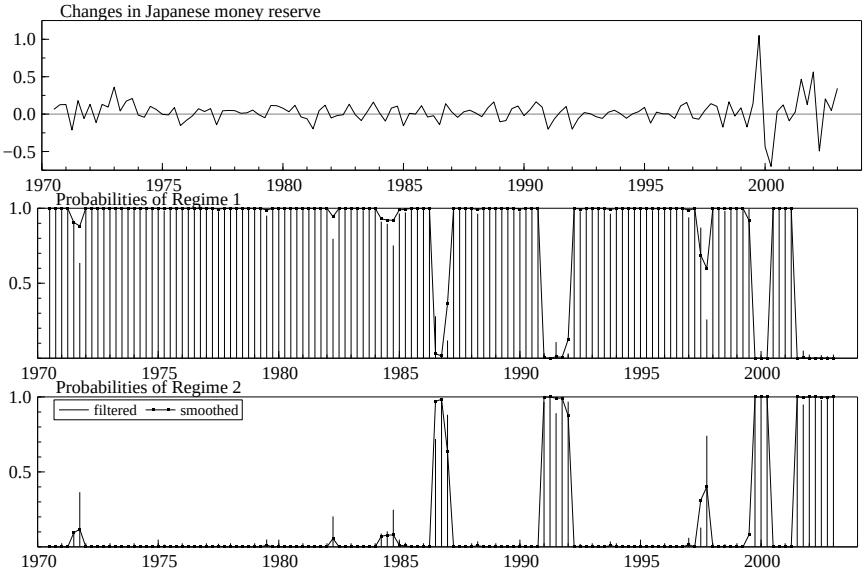
Note: The definition of Model 1 is provided in the main text and Table 1. Statistics less than the critical value (a dot line) indicate parameter stability in the co-integrating vector.

Figure 5: **Hansen and Johansen's Parameter Instability Test (Model 2)**



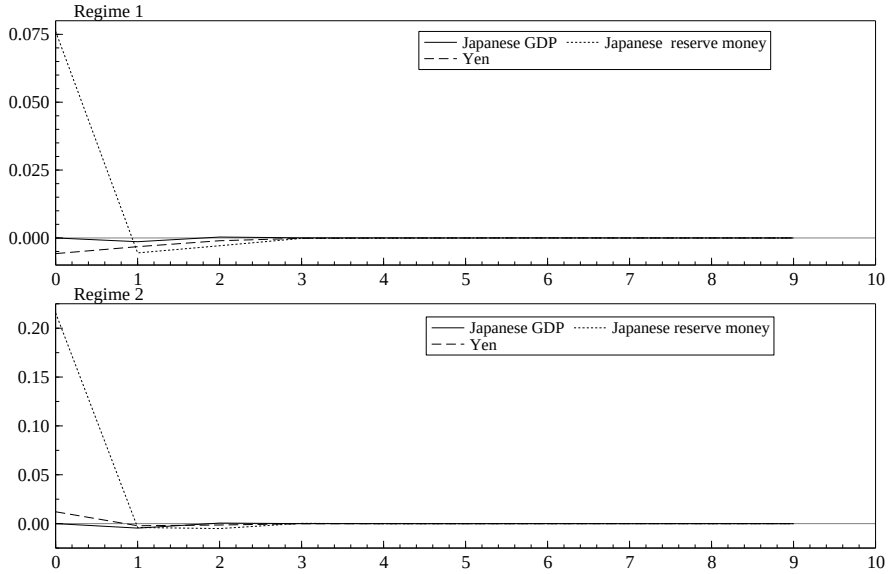
Note: The definition of Model 2 is provided in the main text and Table 1. Statistics less than the critical value (a dot line) indicate parameter stability in the co-integrating vector.

Figure 6: **Probabilities of Regimes**



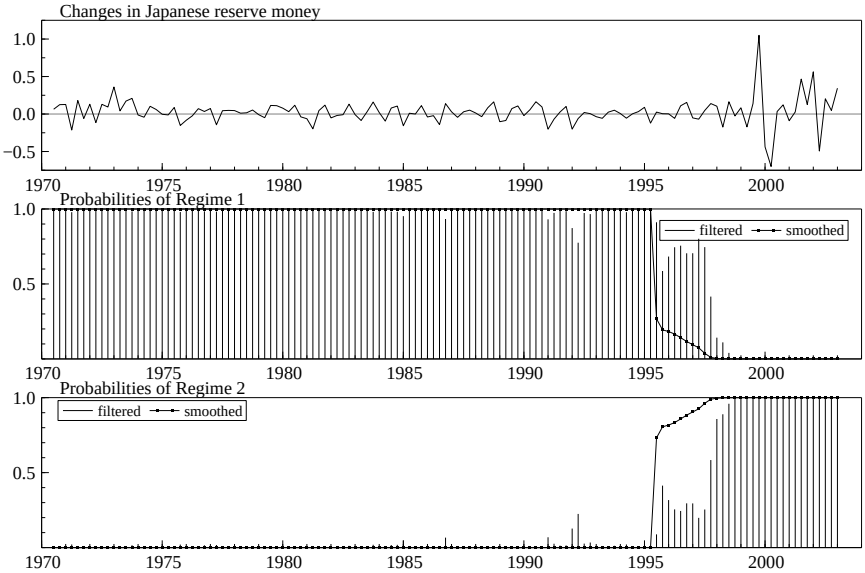
Note: Regime 1 when $\Delta m_{t-1} < 0$ and Regime 2 if $\Delta m_{t-1} \geq 0$, and thus a regime variable is Δm_{t-1}. See Krolzig (1997) for the filtered and smoothed probabilities.

Figure 7: **Impulse Responses: the Shock to Japanese Reserve Money**



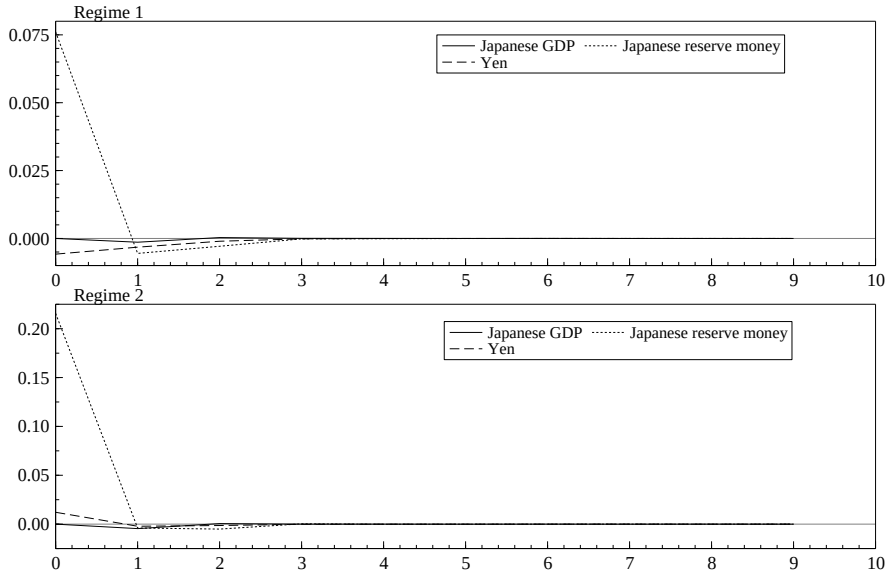
Note: Regime 1 when $\Delta m_{t-1} < 0$ and Regime 2 if $\Delta m_{t-1} \geq 0$.

Figure 8: **Probabilities of Regimes**



Note: Regime 1 for 1970-1995 and Regime 2 for 1995-2003. See Krolzig (1997) for the filtered and smoothed probabilities.

Figure 9: **Impulse Responses: the Shock to Japanese Reserve Money**



Note: Regime 1 for 1970-1995 and Regime 2 for 1995-2003.