Understanding Price Dynamics in Japan's Deflationary Period: A Monetary Perspective*

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[Abstract]

Most economists might agree that "deflation is a monetary phenomenon in the end." However, Japan's deflation still prevails after adopting a series of extremely expansionary monetary policy, namely the zero interest rate policy and quantitative monetary easing. What is happening to price dynamics in Japan? What role did money played in explaining Japan's price fluctuations before and after the recent deflationary period? This paper examines an empirical relationship between money and prices using a time-series approach based on error-correction framework, focusing on the development in the recent deflationary period. The evidence indicates that (i) money actually played a useful role in explaining price fluctuations just before the deflation started around 1998, but (ii) the role disappeared in the 2000's. Forecasting exercises are also performed to have a better understanding of the nature of Japan's deflation from a monetary perspective.

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1. Introduction

Japan's prolonged deflation has been regarded as a key phenomenon in understanding recent development of the Japanese economy. GDP deflator's inflation, for instance, has stayed negative since the late 1990s. As shown in Figure 1, the price level started to fall as early as 1993, but the persistent decline began around 1998. Since then annual inflation rate has been around minus two percent. Despite the recent recovery of the real economy, deflation still prevails in a moderate pace.

One conventional view is to explain inflation/deflation from a monetary perspective. The quantity theory argues that the amount of money should be positively related to the general price level, given that an equilibrium money demand relation holds and velocity stays constant. In Japan, however, money balances expanded substantially during this period due to a series of expansionary monetary policy, i.e., the zero interest rate policy (February 1999-August 2000) and the quantitative easing scheme (March 2001- March 2006) and yet mild deflation still continues. What role has money played in explaining price dynamics in Japan especially in the recent deflationary period?

Bearing that motivation in mind, this paper investigates empirical relationships between money and prices and attempts to answer the above question using a time-series framework. Here we model fluctuations in general prices and assess the role of money by using an error-correction approach. Our investigation consists of three steps. First we confirm that a long-run, cointegrating money demand relationship holds in Japan using the narrow measure of money (M1).[1] Second, we examine short-run price dynamics by setting up an error-correction model and test how useful money has been in explaining fluctuations in prices. Third, we compute out-of-sample forecasts of prices with the error-correction model to study further the role of money in predicting future movements in prices.

Main findings can be summarized as follows. First, the presence of a cointegration in M1 demand can be generally supported by the data. The relationship is also found stable throughout our sample period examined. This provides a basis for setting up an error-correction model of short-run price dynamics. Second, money actually played a

[1] This paper focuses on M1 rather than broader aggregates (M2+CD). The previous evidence did not support the presence of cointegration and short-run predictive content of M2+CD: see e.g. Miyao (2005). We also perform additional exercises (cointegration tests and short-run F tests) using M2+CD and the results can be found in the Appendix.

useful role in explaining price fluctuations just before the deflation started around 1998. But the role disappeared in the 2000's. Third, our short-run model with an error-correction term over-predicts future prices after 1998. More generally, the inclusion of money did not help improve out-of-sample forecasting performance.

This paper is structured as follows. Section 2 briefly reviews existing discussions on the sources of persistent deflation in Japan. Section 3 explains the econometric investigation. Empirical results are presented in Section 4. The final section provides concluding discussions.

2. Sources of Deflation in Japan: A Brief Overview

Sources of Japan's deflation together with economic stagnation since the late 1990s have been extensively discussed by a number of economists both domestic and abroad. There are several explanations, which can be broadly classified into two categories: aggregate demand (AD) side and aggregate supply (AS) side.

On the AD side, factors such as (i)insufficient monetary easing, (ii)deflationary expectation causing a rise in the real interest rate and a subsequent decrease in private spending, (iii) a decrease in government spending (contractionary fiscal policy), (iv) decreased bank lending which would lead to a shortage in real investment for financially constrained firms, and so on. On the AS side, (v) decline in productivity and profitability in the corporate sector (which would be due to global competition together with cheaper imported goods, inefficient corporate management and governance, etc.), (vi) slow adjustment of industrial structure, (vii)inefficiency of resource allocation associated with inefficient bank loans (which helped "zombie" firms to survive), and so on. Using a standard AD-AS framework, those negative AD shocks ((i)-(iv)) are followed by a decline in both prices and output. Negative AS shocks ((v)-(vii)) may lead to a decline in output and a rise in prices. While negative AS shocks such as productivity slowdown is a favored explanation of Japan's lost decade by some economists (such as Hayashi and Prescott (2002)), it may not be necessarily consistent with deflation. Also AD shocks alone would seem to be insufficient because deflation appears too mild, considering severe output stagnation.[2] One might also argue that (viii) global disinflation, due to an

[2] In my view, negative AS shocks can be linked with a decline in aggregate demand. For instance, a persistent decline in macro TFP would lead to a decline in permanent

expanded supply capacity in the world, has played a role to lower marginal cost (i.e. positive AS shocks) and therefore lower general prices in Japan.

Monetary factors are surely on the top of the list in these AD side explanations.[3] The conventional quantity theory also argues that the amount of money should be positively related to the general price level. Almost every economist might agree that "deflation is monetary phenomenon in the end." In Japan, however, money balances expanded substantially during the deflationary period due to a series of expansionary monetary policy, i.e., the zero interest rate policy (February 1999-August 2000) and the quantitative easing scheme (March 2001- March 2006). As shown in Figure 2, money supply (M1) actually increased at a faster pace since the mid 1990s. And yet, mild deflation continued and still prevails. What role has money played in explaining price dynamics in Japan especially in the recent deflationary period?

An empirical relationship between money and prices should be carefully examined by controlling for other endogenous factors. A long-run, or equilibrium, money demand relation, if any, must be taken into consideration in the analysis. We now proceed to econometric investigation on Japan's money and prices in which these potential issues are seriously considered.

3. Econometric Investigation

This section explains the basic strategy of our empirical investigation. We adopt a time-series approach, more specifically an error-correction framework, to study short-run fluctuations in prices from a monetary perspective Key macroeconomic variables used here are output (real GDP), prices (GDP deflator), money (M1) and interest rates (overnight call rate), denoted as Y, P, M, and R, respectively, all in logarithm. Data are quarterly and the full sample period is 1975:1 -2005:4.[4]

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income of households and corporate profits, which in turn cause a persistent decrease in consumption and investment spending. When both AS and AD curves shift leftward, this would generate severe output decline and mild deflation at the same time.

[3] See e.g. Krugman (1998, 2000). Using his "Japan's trap" model, he made a proposal that the Bank of Japan should adopt inflation targeting and commit itself to continue a drastic monetary expansion in the future, say "4% inflation for 15 years."

[4] M1 is seasonally adjusted, monthly average series taken from the Nikkei Database (MT code 32917) and monthly observations are averaged within each quarter to obtain quarterly series. Real GDP and GDP deflator are seasonally adjusted and retrieved from 93SNA. Because 93SNA data are available since 1980, they are linked with

Our investigation consists of three steps. First, we examine whether a long-run, cointegrating money demand relationship holds in Japan using the narrow measure of money (M1). When a cointegration exists in a money demand relationship, it is necessary to include an error-correction term in accounting for changes in prices. The following two systems are considered:

$$(M - P - Y) - \beta_r R = e \qquad (1)$$

$$(M - P) - \beta_y Y - \beta_r R = e \qquad (2)$$

where β_r and β_y are the interest elasticity and income elasticity, respectively, and e is money demand residual (a constant term is excluded in this expression for simplicity). Note that log is taken in all variables including interest rates variable, so that these are sometimes called "double-log" specifications. [5]

Second, after confirming the evidence of cointegration, we examine short-run price dynamics by setting up an error-correction model and test how useful money has been in accounting for fluctuations in prices. When a cointegration exists, a four-variable model of price fluctuations in a vector error-correction (VEC) system can be modeled as:

$$\Delta P_t = a + \sum_{j=1}^{k} b_j \Delta Y_{t-j} + \sum_{j=1}^{k} c_j \Delta P_{t-j} + \sum_{j=1}^{k} d_j \Delta M_{t-j} + \sum_{j=1}^{k} e_j \Delta R_{t-j} + fEC_{t-1} = \varepsilon_t , \qquad (3)$$

where EC_t is an error-correction term, which corresponds to the money demand residual, and ε_t is a disturbance term.

Third, using the error-correction model (3), we compute out-of-sample forecasts of prices and study further the role of money in predicting future movements in prices. Here static, one-step ahead forecasts are employed to focus our attention to predicting prices, rather than the whole endogenous variables in the system.

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corresponding 68SNA data at 1980:1. These SNA statistics can be taken from the Cabinet Office of Japan's web site at www.esri.cao.go.jp/en/sna/menu.html. The call rate series is constructed first by linking the uncollateralized overnight rate (monthly average) after July 1985 and the collateralized rate (monthly average) until June 1985 and then taking average of monthly observations in each quarter. In linking the two series, the mean difference between the two is added to the collateralized rate. These call rate data are taken from the statistics section of the Bank of Japan homepage at www.boj.or.jp. Note also that the starting date here is chosen to avoid possible structural breaks in the early 1970s including the first oil crisis and the exchange rate regime shift.

[5] Miyao(2006) compares "semi-log" forms where the level of interest rates is included in the system with double-log models under the bivariate framework. He argues that use of a double-log form is needed to have a stable, cointegarating relation in M1 demand with near zero interest rates.

Subsample periods that end in the late 1990s and early 2000's are also used to study any possible change in empirical relationships examined: the presence of cointegration, the estimates of a cointegrating relation (i.e. interest and income elasticity of mone demand), the role of money in accounting for price fluctuations, and forecasting performance. Two and four lags are assumed to take into account dynamic dependence in the system.

4. Empirical Evidence

4.1 Cointegration test results

As a preliminary to apply the concept of cointegration, we perform unit root tests for each of the variables in our system: $M-P-Y$, $M-P$, Y, and R. We run the augmented Dickey Fuller (1979) tests of a unit root against no unit root (denoted as ADF), and a modified Dickey-Fuller test based on GLS (generalized least squares) detrending series, a powerful univariate test proposed by Elliot, Rothenberg and Stock (1996) (denoted as DF-GLS). A constant term is included for $M-P-Y$ and R, and time trend is also added for $M-P$ and Y. In all these tests, the optimal lag length is chosen based on SBIC (Schwarz Bayesian information criterion). As shown in Panel A in Table 1, no tests reject the null of a unit root against the alternative of stationarity. Taking the first difference, both ADF and DF-GLS detect strong rejections for all the cases (Panel B). These results imply that each of the underlying variables can be treated as a single unit root process or integrated of order one (I(1)).

We now proceed to the cointegration analysis for equations (1) and (2). Here Johansen's (1988) and Johansen and Juselius's (1990) maximal eigenvalue test of no cointegration against one cointegrating vector (JOH). We use two or four lags in the system.[6] Following the procedure by Cheung and Lai (1993), Osterwald-Lenum's critical values are corrected to account for possible size distortions (over-rejections) in finite samples. Table 2 reports the cointegration test results. The evidence consistently supports the presence of cointegration in both *(M-P-Y, R)* and *(M-P, Y, R)* systems. The results appear fairly robust in terms of the sample period. Thus the evidence seems

[6] We later assume two or four lags in the short-run dynamic system, and it would seem natural to maintain the same lag structure. Note that our test results are unaffected when we use an optimal lag length chosen based on SBIC.

generally in support of the presence of a cointegrating M1 demand relation in Japan.

Given that cointegration in M1 exists, we then estimate the cointegrating vector, which corresponds to the interest elasticity β_r and income elasticity β_y in the money demand systems (1) and (2). We adopt the dynamic OLS procedure of Saikkonen (1991) and Stock and Watson (1993). Two or four leads and lags are used in these estimations together with the Newey-West standard error with two or four lags truncation.

Table 3 presents the estimation results. The estimated interest elasticity β_r with the bivariate system looks very much stable across these sample periods. The point estimates range from -0.091 to -0.103 for two lags case, and from -0.097 to -0.111 for four lags case. Using the trivariate system, both β_r and β_y are estimated. The point estimates again looks similar, although there is some variation in this case. Overall, our results suggest that the cointegarting relationship in M1 demand can be regarded as fairly stable, especially in the bivariate framework. Figure 3 displays a scatter plot of $M-P-Y$ and R. The relationship indeed looks very much stable even in the recent years of deflation and economic stagnation.

4.2 The role of money in explaining price fluctuations

After confirming the evidence of cointegration, we then estimate short-run price dynamics using an error-correction framework (equation (3) above) and test how useful money has been in accounting for fluctuations in prices. The error-correction term is the estimated residual of money demand relation for each sample period. For example, the error correction term (EC) in the (M-P-Y, R) model with two lags, 1975-1998 subsample is: $EC = (M-P-Y) - (-0.091)\,R$.

Table 4 reports F statistics testing that these coefficients on money and the error-correction term are jointly zero in equation (3). The results indicate that money balances and associated money demand residuals are statistically significant until the end of the 1990s but they are no longer significant in the 2000's. This is true for both bivariate and trivariate systems.

The end of the 1990s (around 1998-1999) was the time when prolonged (yet mild) deflation actually started (recall Figure 1). This was also around that time when more aggressive monetary easing began (the zero interest rate policy in February 1999 and subsequently the quantitative easing policy in March 2001). Accordingly money balances increased substantially after the late 1990s, as shown in Figure 2.

This suggests that money had indeed played a useful role in explaining price fluctuations before deflation started, but the role disappeared as the fall in prices continued in the 2000's.

4.3 Out-of-sample forecasts of prices

Using the estimated model of equation (3), we calculate out-of-sample, static forecasts of price dynamics. Our focus here is the deflationary period, so we forecast GDP deflator after 1998. For instance, one-step ahead forecasts of a change in GDP deflator for 1999:1-2005:4 are computed using the estimated model with the 1975-1998 subsample and feeding in actual (lagged) values of explanatory variables in the model.

Figure 4 displays GDP deflator and its forecasts (both in levels). Forecast series are computed shown in dotted lines and actual series in real lines. Graph A shows the forecast series based on the 1975-1998 model. The graph indicates a gradual rise, rather than a fall, in prices after 1999. This is in part because positive money demand residuals induce a subsequent rise in prices through error-correction mechanism. Recall, however, that monetary variables including the error-correction term are no longer significant in the 2000's as indicated in the F test results of Table 4. Use of the (irrelevant) error-correction term in the 2000s may lead to such a persistent over-prediction.

Similar exercises are performed using the estimated models with 1975-2000 and 1975-2002 subsamples. The forecast series based on these models are shown in Graph B (2001:1-2005:4) and Graph C (2003:1-2005:4), respectively. In Graph B, the over-prediction is still observed for the initial forecasting period, but subsequently the forecast series exhibits a persistent fall in prices, which is largely consistent with the decline in GDP deflator actually observed. In Graph C, the forecast series tracks the actual series reasonably well, which indicates a good forecasting performance of these error-correction models.[7]

[7] Forecasting exercises using four lags are also performed. With four lags, similar results are obtained.

Then, is the error-correction term, or monetary factor in general, really needed to have these good forecasts partly shown in Figure 4? To answer this question, we further conduct similar forecasting exercises without error-correction mechanism. To be more precise, we consider following alternative models with no error-correction term:

$$\Delta P_t = a + \sum_{j=1}^{k} b_j \Delta Y_{t-j} + \sum_{j=1}^{k} c_j \Delta P_{t-j} + \sum_{j=1}^{k} d_j \Delta M_{t-j} + \sum_{j=1}^{k} e_j \Delta R_{t-j} = \varepsilon_t , \qquad (4)$$

and,

$$\Delta P_t = a + \sum_{j=1}^{k} b_j \Delta Y_{t-j} + \sum_{j=1}^{k} c_j \Delta P_{t-j} + \sum_{j=1}^{k} e_j \Delta R_{t-j} = \varepsilon_t , \qquad (5)$$

In equation (4), the error-correction term is simply excluded from equation (3). Equation (5) excludes not only the EC term, but also money balances itself. Now we are able to compare forecasting performance these alternative models.

Figure 5 displays the forecasting results with these models (Graphs A, B, and C). The forecast series based on equations (4) and (5) are denoted as VAR1 and VAR2, respectively. It is apparent in each graph that the forecast series without using EC term or money balances (VAR1 or VAR2) outperform the original forecast with EC term (VEC). Accordingly, we may conclude that the role of money or money demand residuals seem fairly limited in the recent deflationary period from the forecasting perspectives.

5. Discussions

How do we interpret these results from perspectives of the Japanese macro economy and macroeconomic policy management?

Suppose many observers of the Japanese economy at the time of 1998 viewed equation (3) as a relevant model that explain macroeconomic fluctuations and especially price dynamics in Japan. Our evidence suggests that monetary factors in general had played a reasonably important role in explaining price fluctuations. If this is the case, then the over-prediction in Graph A might be interpreted that a persistent decline in the actual series was regarded as "a surprise" or "unexpected". In other words, as monetary expansion and associated positive money demand residuals continued around the time of 1998-1999, many people might have expected a future increase in prices, rather than a decline. Then unexpected deflation may have caused unexpected income redistribution from debtors to lenders. As debtors tend to have higher propensity to spend than lenders, this income redistribution might have been an additional source of economic stagnation (this is known as "debt deflation mechanism" by Irving Fisher).

In the meantime, the over-prediction gradually disappeared as suggested in Graphs B and C. People may have learned from the forecast error that caused the unexpected fall in prices and consequently they adjusted their behavior not to take monetary factors seriously in predicting future price fluctuations. It seems that money had nothing to do with the general price level in the 2000's. And this is contrary to the conventional argument of the quantity theory.

As a final remark, we should stress that our evidence is in support of an equilibrium money demand relationship --- which is a key presumption of the quantity theory --- but at the same time is *not* support of the main argument of the quantity theory that there is a positive one-to-one relationship between money and prices. We are able to interpret these pieces of evidence consistently if we observe the series of income velocity. The classical quantity theory argument requires that velocity remains stable with real output being given at the full-employment level. Yet, as Figure 6 shows, velocity in Japan declines to a great extent after mid 1990s. It is obvious from the quantity equation MV=PY that an increase in M is not followed by an increase in P when V declines at the same time. Note again that the quantity equation (i.e. an equilibrium money demand relation) still holds true as interest rates were lowered and 1/V (or Marshall's *k*) increased since the mid 1990s. In Figure 6, the estimated velocity (the dotted line) tracks the actual series (the solid line) fairly well.

It remains a challenge for economic profession to understand the underlying mechanism of this apparent breakdown in the money-price relationship in Japan. Global disinflation due to a worldwide increase in production capacity together with low wages would seem to be a key non-monetary factor, and this possibility should be thoroughly investigated in future research.

References

Cheung,Yin-Wong and Kon S. Lai, 1993. ``Finite-Sample Sizes of Johansen's Likelihood Ratio Tests for Cointegration," *Oxford Bulletin of Economics and Statistics* 55, 313-328.

Dickey, D. A. and W. A. Fuller, 1979. ``Distribution of the Estimators for Autoregressive Time Series with a Unit Root," *Journal of American Statistical Association* 74, 427-431.

Elliott, Graham, Thomas J. Rothenberg, and James H. Stock, 1996. ``Efficient Tests for an Autoregressive Unit Root," *Econometrica* 64, 813-836.

Friedman, Milton and Anna J. Schwartz, 1963, *A Monetary History of the United States: 1867-1960*, Princeton University Press..

Fuller, W. A., 1976. *Introduction to Statistical Time Series*, New York: John Wiley and Sons.

Hayashi, Fumio and Edward C. Prescott, 2002 "The 1990s in Japan: A Lost Decade," *Review of Economic Dynamics* 5, 206-235.

Johansen, Soren, 1988. ``Statistical Analysis of Cointegrating Vectors," *Journal of Economic Dynamics and Control* 12, 213-54.

Johansen, Soren and Katarina Juselius, 1990. ``Maximum Likelihood Estimation and Inference on Cointegration - With Application to the Demand for Money," *Oxford Bulletin of Economics and Statistics* 52, 169-210.

Krugman, Paul. 1998. ``It's Baaack! Japan's Slump and the Return of the Liquidity Trap," *Brooking Papers on Economic Activity* 2, 137-205.

Krugman, Paul. 2000. ``Thinking about the Liquidity Trap," *Journal of the Japanese and International Economies* 14, 221-237.

Miyao, Ryuzo, 2005.``Use of Money Supply in the Conduct of Monetary Policy: Re-examining the Time-Series Evidence, " *Japanese Economic Review* 56, 165-187.

Miyao, Ryuzo, 2006.``The Stability of Money Demand and Liquidity Traps in Japan," mimeo. Kobe Univesitiy, June 2006.

Osterwald-Lenum, M., 1992.``A Note with Quantiles of the Asymptotic Distribution of the Maximum Likelihood Cointegration Rank Test Statistics," *Oxford Bulletin of Economics and Statistics* 54, 461-472.

Saikkonen, Pentti, 1991.``Asymptotically Efficient Estimation of Cointegrating Regressions," *Econometric Theory* 7, 1-21.

Stock, James. H. and Mark. W. Watson, 1993.``A Simple Estimator of Cointegrating Vectors in Higher Order Integrated Systems," *Econometrica* 61, 783-820.

Table 1. Unit Root Test Results

Variable	ADF	DF-GLS
	A. In levels	
$M-P-Y$	2.15(1)	1.88(1)
$M-P$	-0.75(1)	-0.20(1)
Y	-0.78(0)	-1.03(3)
R	2.06(5)	2.90(5)
	B. In first differences	
$\Delta(M\text{-}P\text{-}Y)$	-6.74(0)**	-6.72(0)**
$\Delta(M\text{-}P)$	-6.33(0)**	-6.28(0)**
ΔY	-3.84(2)**	-3.85(2)**
ΔR	-7.84(4)**	-7.82(5)**

Notes: This table reports statistics testing for a unit root for a reciprocal of M1 velocity ($M-P-Y$), real M1($M-P$), real output (Y), call rate (R), all in logarithm. ADF is the augmented Dickey-Fuller (1979) test of a unit root against no unit root, and DF-GLS is a Dickey-Fuller test based on GLS-detrended series, proposed by Elliott, Rothenberg and Stock (1996). A constant term is included in both tests. In all these tests, the optimal lag length is chosen based on SBIC and is shown in parentheses. The sample period is 1975:1-2005:4. Critical values, tabulated by Fuller (1976), Elliott, Rothenberg and Stock (1996) are:

	10%(†)	5%(*)	1%(**)
ADF	-2.58	-2.89	-3.51
DF-GLS	-1.61	-1.95	-2.60

Table 2. Cointegration Test Results

Lag	1975:1-1998:4	1975:1-2000:4	1975:1-2002:4	1975:1-2005:4
		A. *(M-P-Y, R) system*		
(Lag=2)	22.41**	24.53**	22.29**	18.44*
(Lag=4)	19.95*	20.32*	15.93 †	13.22
		B. *(M-P, Y, R)* system		
(Lag=2)	23.91*	32.37**	38.85**	35.32**
(Lag=4)	21.24 †	34.38**	21.22 †	20.37

Notes: This table reports statistics testing for a cointegration in M1 demand systems (M-P-Y, R) and (M-P, Y, R). The testing method is Johansen's (1990) maximal eigenvalue test of no cointegration against one cointegrating vector. The full sample (1975:1-2005:4) as well as subsamples that ends in 1998:4, 2000:4 and 2002:4 are used. 2 or 4 lags are included in the system. Critical values are tabulated by Osterwald-Lenum (1992). Following the procedure by Cheung and Lai (1993), Osterwald-Lenum's critical values are corrected to account for possible size distortions in finite samples.

		(lag = 2)			(lag=4)		
		10%(†)	5%(*)	1%(**)	10%(†)	5%(*)	1%(**)
Bivariate	1975-1998	14.3	16.3	21.0	14.9	17.1	22.0
	1975-2000	14.2	16.3	21.0	14.8	16.9	21.8
	1975-2002	14.2	16.2	20.9	14.7	16.8	21.7
	1975-2005	14.2	16.1	20.8	14.6	16.7	21.5
Trivariate	1975-1998	19.7	22.3	27.1	21.1	23.9	29.1
	1975-2000	19.6	22.2	27.0	20.9	23.6	28.8
	1975-2002	19.6	22.1	26.9	20.7	23.4	28.5
	1975-2005	19.4	22.0	26.7	20.5	23.1	28.1

Table 3. Estimates of Money Demand Elasticities

Estimates		1975:1-1998:4	1975:1-2000:4	1975:1-2002:4	1975:1-2005:4
		A. *(M-P-Y, R) system*			
β_r	(lag=2)	-0.091	-0.103	-0.103	-0.100
		(0.013)	(0.007)	(0.005)	(0.003)
	(lag=4)	-0.097	-0.109	-0.111	-0.101
		(0.016)	(0.013)	(0.008)	(0.003)
		B. *(M-P, Y, R)* system			
β_r	(lag=2)	-0.138	-0.141	-0.132	-0.114
		(0.013)	(0.005)	(0.004)	(0.003)
	(lag=4)	-0.136	-0.151	-0.139	-0.114
		(0.007)	(0.007)	(0.004)	(0.004)
β_y	(lag=2)	0.647	0.637	0.658	0.703
		(0.039)	(0.037)	(0.035)	(0.036)
	(lag=4)	0.666	0.638	0.660	0.700
		(0.037)	(0.038)	(0.037)	(0.040)

Notes: This table reports estimates of money demand elasticities: interest elasticity β_r and income elasticity β_y in the bivariate (M-P-Y, R) system and the trivariate (M-P, Y, R) system. They are estimated by using the dynamic OLS method proposed by Saikkonen (1993) and Stock and Watson (1993). Two or four leads and lags are used in the estimation. The Newey-West standard error is computed with two or four lags truncation and shown in parentheses. .

Table 4. F Statistics Testing for the Role of Money in the Price Fluctuations

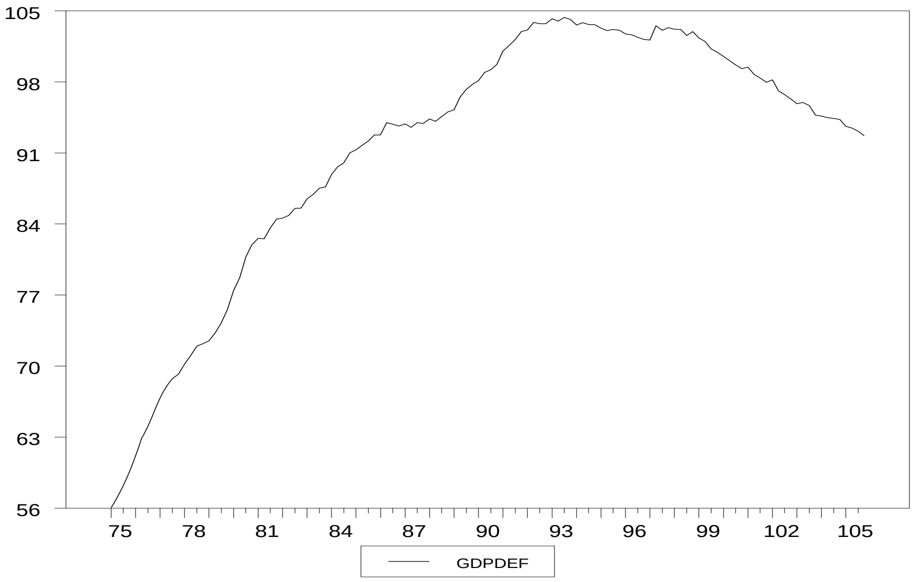
Lag	1975:1-1998:4	1975:1-2000:4	1975:1-2002:4	1975:1-2005:4
		A. *(M-P-Y, R) system*		
(lag=2)	4.82**	3.81*	2.04	1.68
	(0.004)	(0.013)	(0.11)	(0.18)
(lag=4)	2.95*	2.58*	2.11 †	1.83
	(0.018)	(0.033)	(0.072)	(0.11)
		B. *(M-P, Y, R)* system		
(lag=2)	3.00*	2.31 †	1.10	0.94
	(0.035)	(0.082)	(0.35)	(0.42)
(lag=4)	2.33 †	2.03 †	1.81	1.60
	(0.051)	(0.083)	(0.12)	(0.17)

Notes: This table reports F statistics testing that coefficients on money and the error-correction term are jointly zero in the price equation (equation (3) in the text). Two and four lags are used in the estimating equation. P-values are shown in parentheses. **, * and † indicate rejections at 1%, 5%, and 10% significance levels, respectively.

Figure 1. GDP Deflator

—1975:1-2005:4—

A. Level (index: 2000=100)



B. Inflation rate (annual growth rate, %)

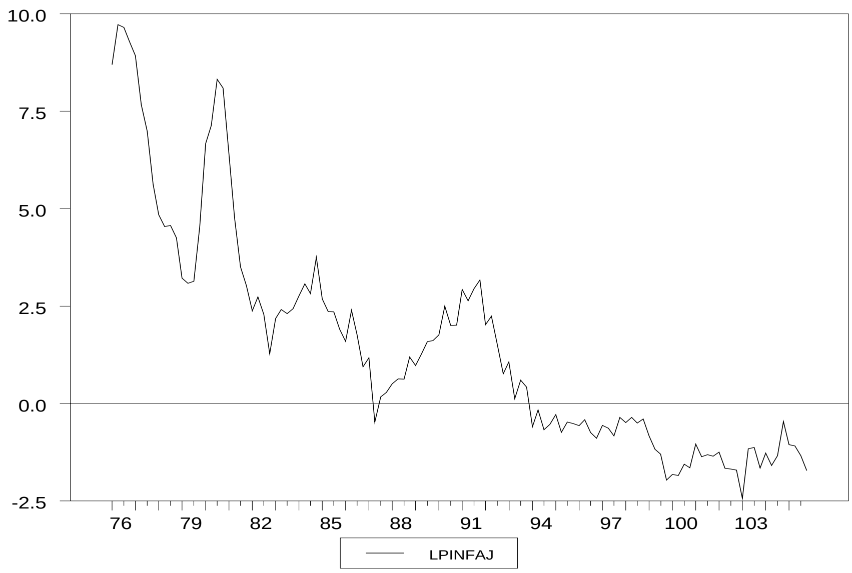


Figure 2. Money Balances

—1975:1-2005:4, M1, trillion yen—

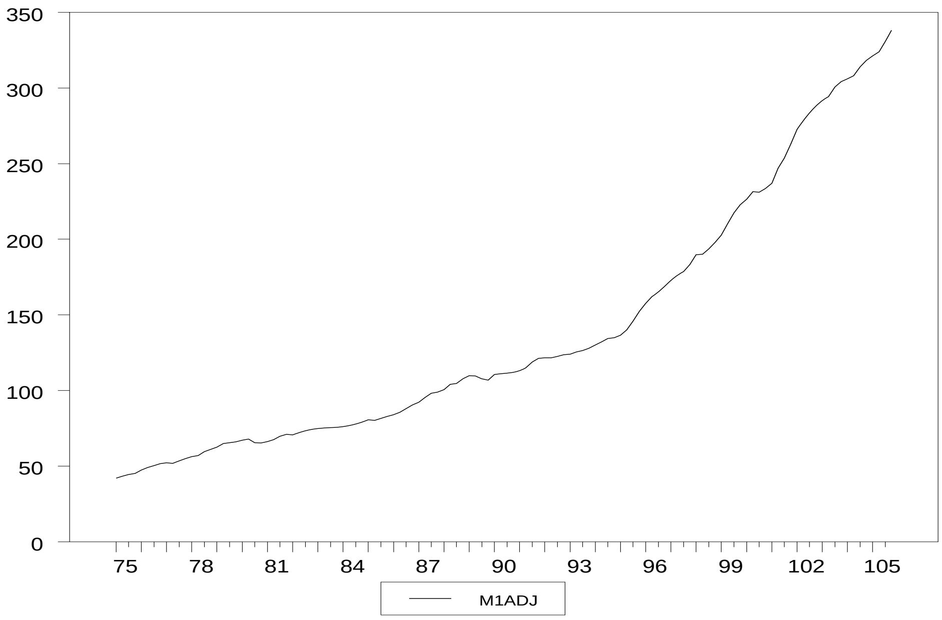


Figure 3. Scatter Plot of (M-P-Y, R)

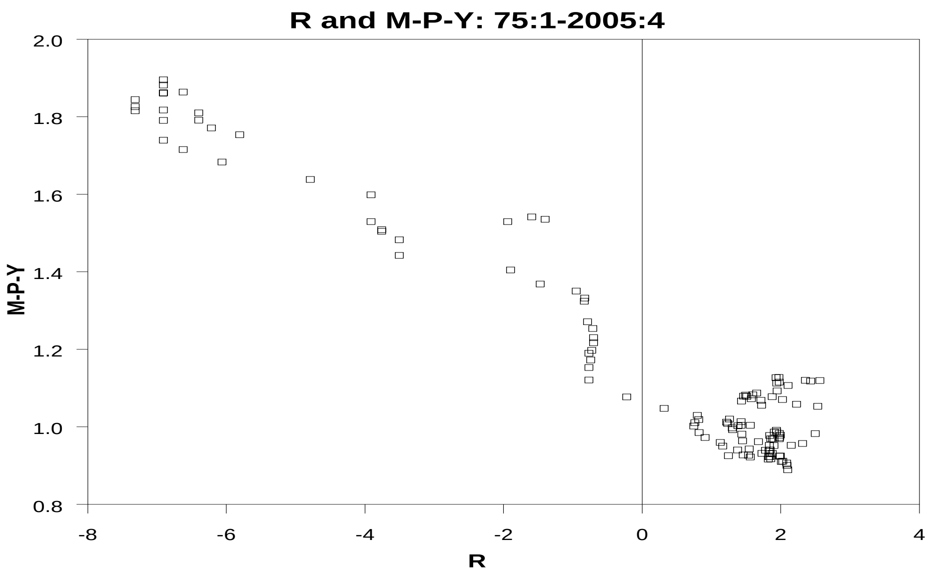
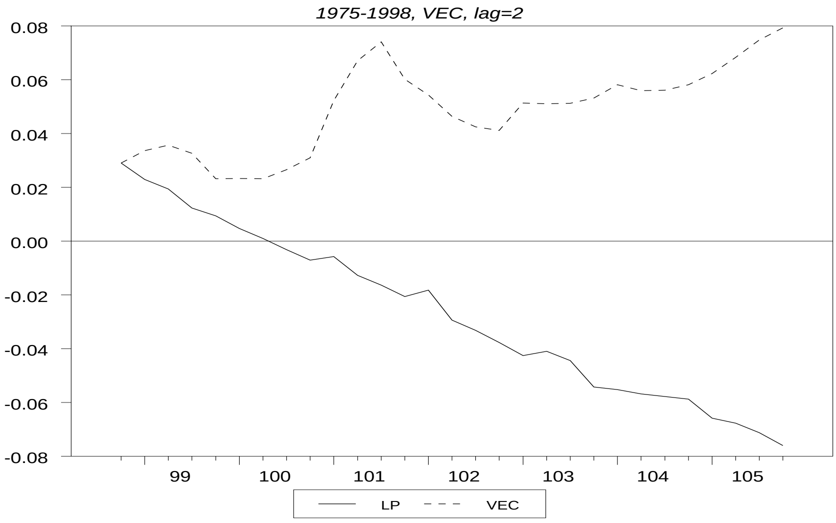


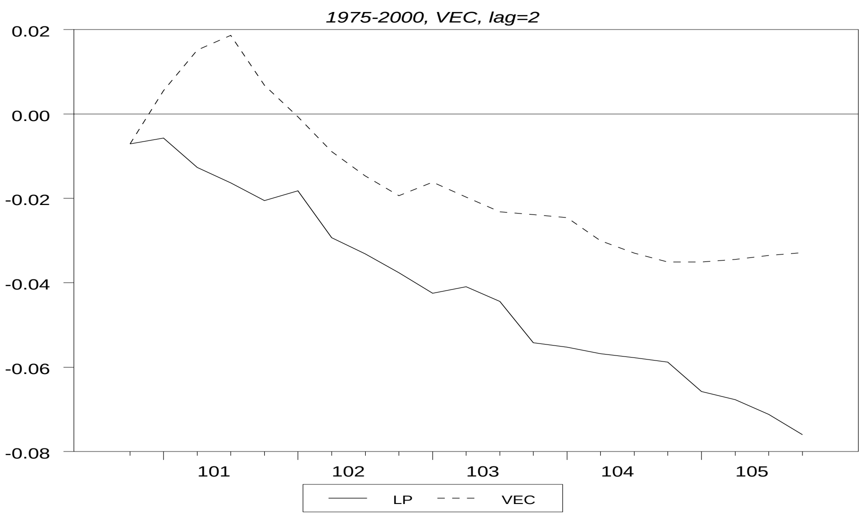
Figure 4. Out-of-sample Forecast of GDP Deflator

— Forecasts with EC model (dotted line) and actual series (real line) —

A. Based on 1975-1998 model with EC term



B. Based on 1975-2000 model with EC term



C. Based on 1975-2002 model with EC term

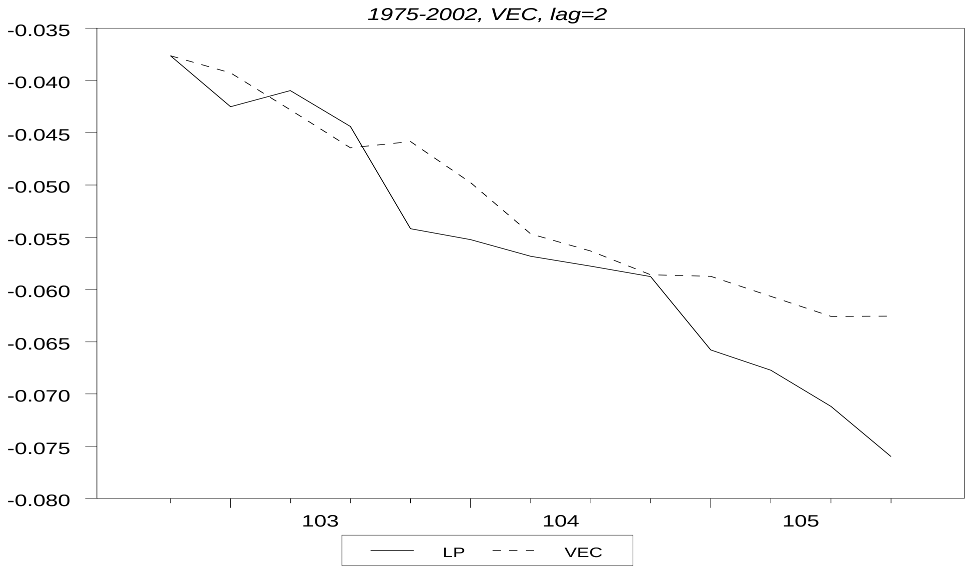
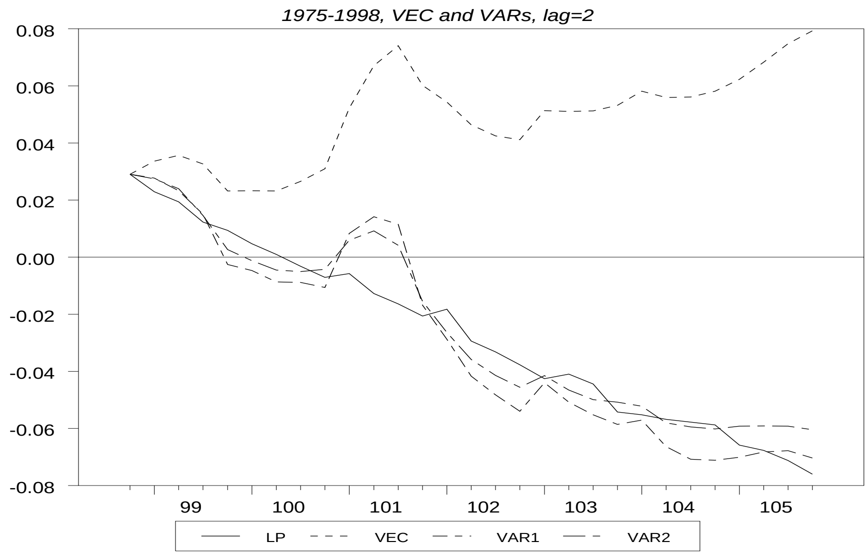


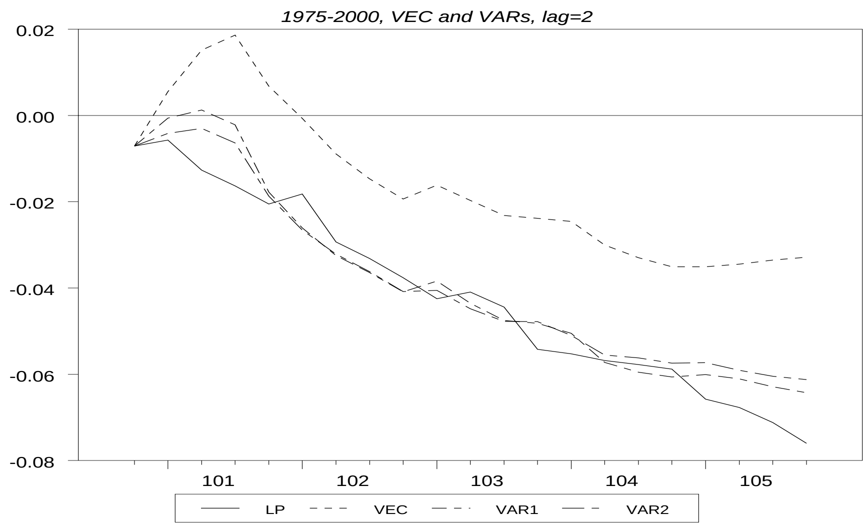
Figure 5. Out-of-sample Forecasts of GDP Deflator

— Forecasts with VEC and VAR models (dotted line) and actual series (real line) —

A. Based on 1975-1998 models: VEC, VAR1, VAR2



B. Based on 1975-2000 models: VEC, VAR1, VAR2



C. Based on 1975-2002 model: VEC, VAR1, VAR2

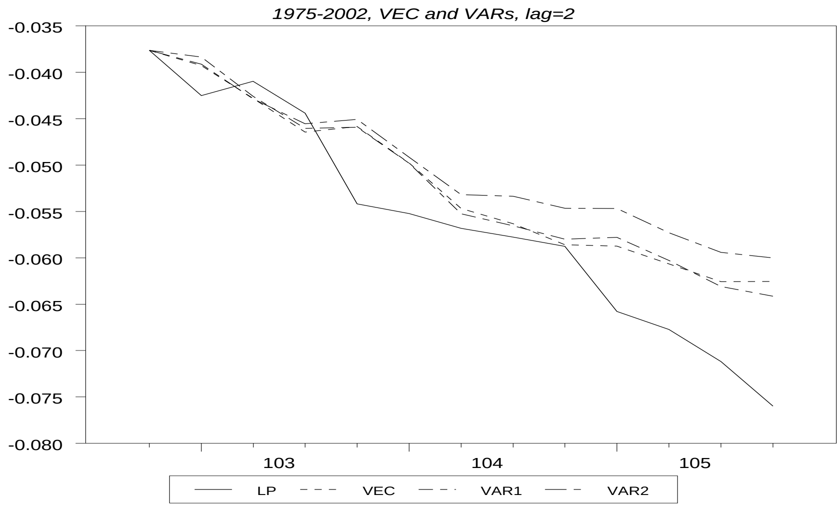
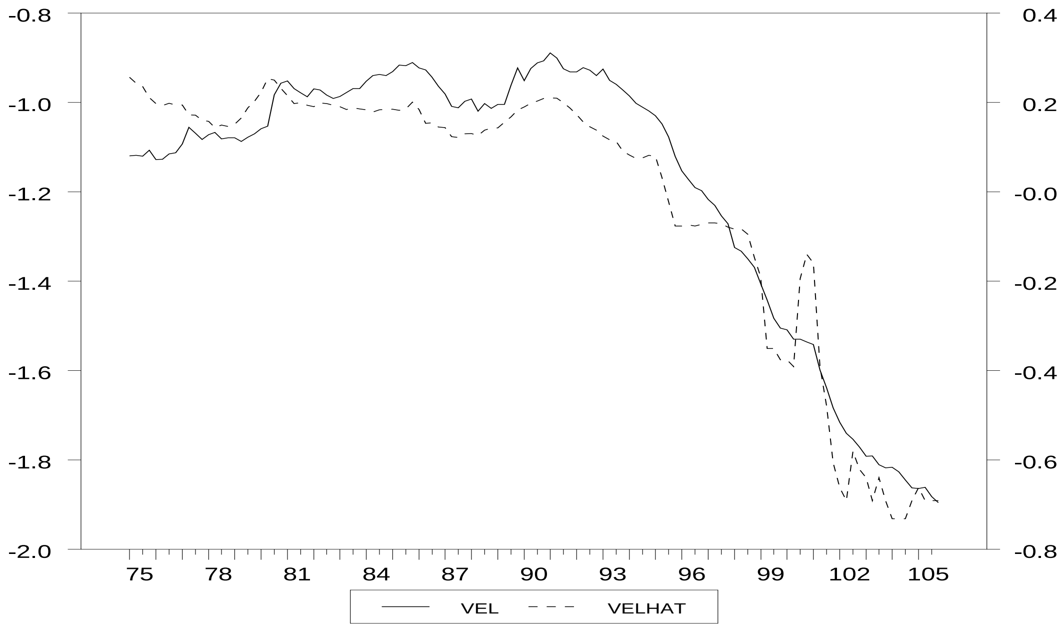


Figure 6. Velocity, 1975-2005

—Actual ($Y+P-M$, real line) and estimated ($1.0^{*}R$, dotted line)—



＜Appendix: Results with M2+CD＞

Table A-1. Cointegration Test Results

Lag	1975:1-1998:4	1975:1-2000:4	1975:1-2002:4	1975:1-2005:4
		A. *(M-P-Y, R) system*		
(Lag=2)	11.37	11.54	12.67	9.67
(Lag=4)	9.68	12.00	9.49	6.59
		B. *(M-P, Y, R)* system		
(Lag=2)	12.52	15.89	17.50	18.82
(Lag=4)	15.88	20.64	19.27	19.92

Notes: This table reports statistics testing for a cointegration in M2 demand systems *(M-P-Y, R)* and *(M-P, Y, R)*. The testing method is Johansen's (1990) maximal eigenvalue test of no cointegration against one cointegrating vector. The full sample (1975:1-2005:4) as well as subsamples that ends in 1998:4, 2000:4 and 2002:4 are used. Two and four lags are included in the system. Critical values are tabulated by Osterwald-Lenum (1992). Following the procedure by Cheung and Lai (1993), Osterwald-Lenum's critical values are corrected to account for possible size distortions in finite samples.

		(lag = 2)			(lag=4)		
		10%(†)	5%(*)	1%(**)	10%(†)	5%(*)	1%(**)
Bivariate	1975-1998	14.3	16.3	21.0	14.9	17.1	22.0
	1975-2000	14.2	16.3	21.0	14.8	16.9	21.8
	1975-2002	14.2	16.2	20.9	14.7	16.8	21.7
	1975-2005	14.2	16.1	20.8	14.6	16.7	21.5
Trivariate	1975-1998	19.7	22.3	27.1	21.1	23.9	29.1
	1975-2000	19.6	22.2	27.0	20.9	23.6	28.8
	1975-2002	19.6	22.1	26.9	20.7	23.4	28.5
	1975-2005	19.4	22.0	26.7	20.5	23.1	28.1

Table A-2. F Statistics Testing for the Role of Money in the Price Fluctuations

Lag	1975:1-1998:4	1975:1-2000:4	1975:1-2002:4	1975:1-2005:4
(lag=2)	2.14	2.57 †	2.19	2.85 †
	(0.12)	(0.08)	(0.12)	(0.06)
(lag=4)	0.58	0.97	0.94	0.95
	(0.67)	(0.43)	(0.44)	(0.44)

Notes: This table reports F statistics testing that coefficients on money and the error-correction term are jointly zero in the price equation (equation (3) in the text). Two and four lags are used in the estimating equation. P-values are shown in parentheses. **, * and † indicate rejections at 1%, 5%, and 10% significance levels, respectively.