An Examination of the Macro Rational Expectations Hypothesis for the High Growth Period: The Case of Japan and Korea

Sung Hwi Lee*

This paper investigates the joint MRE hypothesis for high growth period of Japan and Korea. One of the major finding of the paper is that rational expectations hypothesis is not rejected even under the rapidly changing circumstances of high economic growth. These results support the modeling strategies in which expectations are assumed to be rational. The fact that we have contrasting results for the neutrality proposition for Japan and Korea may be an indirect evidence of the unimportant of the real effect of the expected overall growth money supply. The total effect of the anticipated M2 on real output has been small at the most. (*JEL* Classification: E52)

I. Introduction

Macro Rational Expectations Hypothesis has caused heated debates both on the theoretical level and on the empirical level, since the 1970's. This hypothesis, advanced by Lucas, Sargent, and Wallace, asserts that Keynesian feedback policy rules would not have any effects on business fluctuations. More specifically, it maintains that anticipated changes in money supply (or anticipated changes in aggregate demand variable) would not have any systematic influence on real eco-

*Professor of Economics, Seoul National University. This paper was written while the author was a visiting scholar at the Bank of Japan. The author is grateful to the Institute for Monetary and Economic Studies and its staff members for the fruitful research environment, and useful discussions and comments on the paper. The views expressed in the paper are entirely the responsibility of the author as are any remaining flaws of the paper.
[**Seoul Journal of Economics** 1996, Vol. 9, No. 4]

nomic activities. The first empirical investigation of the MRE hypothesis was advanced by Barro (1977). Barro found that for the United States, anticipated changes in the money supply did not have any effect on real variables. His findings have caused a tremendous repercussion on the profession.

MRE hypothesis is a joint hypothesis of policy neutrality proposition and rational expectation hypothesis. At first the policy neutrality proposition had drawn a disproportionately large attention. The policy neutrality proposition is a proposition which would prevail in a frictionless economy. One has to view this proposition as an attempt to model a "first approximation" to the real economy or a kind of research strategy to build a frictionless world model first. In the actual economies there are various kinds of frictions; frictions on the flow of information, frictions on the price adjustment, and various other frictions, which cause adjustment costs. Therefore, more generalized models, which take these friction factors into account, can restore an effective monetary policy. Even though the neutrality proposition has a rather limited applicability in the actual economy, it still is a useful first approximation and needs to be investigated extensively.

The main purpose of this paper to test MRE hypothesis during the high growth period. The basic idea is to put the tests of MRE hypothesis and its two components of policy neutrality proposition and rational expectations hypothesis under more extreme circumstances to see whether these hypotheses still hold. If these hypotheses can be supported under a more tumultuous and fast-changing circumstances, it could be interpreted as a more strong evidence for the hypothesis. The high growth period would supply the very useful circumstances for the test.

In this paper we are going to examine MRE hypothesis during the high growth period for the cases of Japan and Korea. The test method is very well established one. However, it is very complicated computationally and hard to handle consistently. Therefore, it would he useful if one author applies the same method to several countries and compare the test results consistently. The author chose Japan and Korea, not because these two economies have same structural characteristics, but because the two countries can be used as excellent examples of high growth period. In the Section II we will briefly overview the literature and introduce the methodology that we are going to use in the empirical analysis. In the Section III we will present the empirical results for Japan and Korea, based on the M2 growth as the aggregate demand variable. In the Section IV a brief conclusion will follow.

II. Brief Overview and Mishkin Methodology

Barro (1977) started the testing of the policy neutrality proposition under the maintained hypothesis of rational expectations in his original paper. Briefly summarizing, Barro's test is a two-step procedure. In the first step, money growth forecasting equation, which related the rate of growth of the money supply to its own lagged terms, the lagged unemployment rate, and a current fiscal policy variable, is estimated. In the second step, the residuals from the estimated forecasting equation were taken as the unexpected part of the money growth. Barro included these residuals in his unemployment equation, together with other explanatory variables in order to estimate the effect of unexpected money supply on real variables. The equation has been estimated for the period of 1946 and 1973. The alternative hypothesis Barro tested was whether the expected growth rates of the money supply affected the level of unemployment. Barro's test rejected strongly the hypothesis that expected money growth affect the real variables.

Major criticism of Barro's test from the methodological point of view is, among others, as follows. While Barro assumes rational expectation, his empirical study fails to fully utilize the cross-equation constraints between the money supply equation and the output equation. The cross-equation constraints are an essential part of the Lucas-Sargent-Wallace type model. Theoretically speaking, these corss-equation constraints incorporate the dependence of private agents' decision rule on the government's decision rule into the model. In other words, these restrictions summarize the dependence of private agents' strategies on the government strategies, which plays the key role in the derivation of policy neutrality proposition.[1] Moreover, Barro's method has several other undesirable aspects from the empirical point of view.

A new empirical methodology was developed by Mishkin (1982 and 1983). Mishkin's methodology has two important innovations. One is that it incorporates the corss-equation constraints into the model and, as a result, it can test the neutrality proposition with a more efficient parameter estimates. The second innovation is that, while Barro's methodology assumes rational expectations, Mishkin's can test rational

[1]Refer to chapter 1 of Sargent (1986) for the details of the role of cross-equation constraints in the economic agent's decision rules.

expectations hypothesis separately. In this paper we are applying Mishkin's method to the high growth period of Japan and Korea to test (1) the rational expectations hypothesis, (2) the policy neutrality proposition and (3) the joint Macro Rational Expectations hypothesis of (1) and (2)

A brief summary of the Mishkin's method will follow.[2] The tests are based on the MRE model of the form.

$$y_t = \tilde{y}_t + \sum_{i=0}^{n} c_1(X_{t-1} - X^e_{t-1}) + \varepsilon_t. \tag{1}$$

where y_t = real output at time t

$\tilde{y}_t$ = natural level of real output

X_t = aggregate demand policy variable, such as M2 growth, nominal GNP growth, or inflation rate

X^e_t = anticipated X_t conditional on the information at time $t-1$

c_1 = coefficients

ε_t = error term

A forecasting equation of the aggregate demand variable that is needed to generate anticipated values of x_t is

$$X_t = Z_t \cdot g + u_t. \tag{2}$$

where Z_t = a vector of variables used to forecast X_t available at time $t-1$

g = a vector of coefficients

u_t = an error term which is assumed to be uncorrelated with any information available at time $t-1$

In order to incorporate rational expectations hypothesis into the model, one has to take expectations of equation (2), conditional on the information available at time $t-1$:

$$X^e_t = Z_t \cdot g. \tag{3}$$

And substituting equation (3) into equation (1), we have

$$y_t = \tilde{y}_t + \sum_{i=0}^{n} c_1(X_{t-1} - Z_{t-1} \quad g) + \varepsilon_t. \tag{4}$$

The MRE hypothesis embodies two separate hypotheses. The neutrality proposition implies that deviations of output from their natural lev-

[2]Refer to Mishkin (1983) for the original explanation of the MRE hypothesis testing methodology, using cross-equation constraints.

els are not correlated with the anticipated movements in aggregate demand variable. That is, $d_i = 0$ for all i in the following equation.

$$y_t = \tilde{y}_t + \sum_{i=0}^{n} c_i (X_{t-i} - X^e_{t-i}) + \sum_{i=0}^{n} d_i \cdot X^e_{t-i} + \varepsilon_t. \quad (5)$$

Rationality of expectation implies that equation (5) can be rewritten as follows.

$$y_t = \tilde{y}_t + \sum_{i=0}^{n} c_i (X_{t-i} - Z_{t-i} \cdot g) + \sum_{i=0}^{n} d_i \cdot Z_{t-i} \cdot g + \varepsilon_t. \quad (6)$$

The joint nonlinear estimation procedure can be used to estimate the system as a whole, taking the corss-equations constraints fully into account. We can consider the following four systems.

(I) Rational and Neutral System

$$X_t = Z_{t-1} \cdot g + u_t, \quad (2)$$

$$y_t = \tilde{y}_t + \sum_{i=0}^{n} c_i (X_{t-i} - Z_{t-i} \cdot g) + \varepsilon_t. \quad (4)$$

(II) Rational and Nonneutral system

$$X_t = Z_{t-1} \cdot g + u_t, \quad (2)$$

$$y_t = \tilde{y}_t + \sum_{i=0}^{n} c_i (X_{t-i} - Z_{t-i} \cdot g) + \sum_{i=0}^{n} d_i \cdot Z_{t-i} \cdot g + \varepsilon_t. \quad (6)$$

(III) Nonrational and Neutral System

$$X_t = Z_{t-1} \cdot g + u_t, \quad (2)$$

$$y_t = \tilde{y}_t + \sum_{i=0}^{n} c_i (X_{t-i} - Z_{t-i} \cdot g^*) + \varepsilon_t. \quad (4a)$$

(IV) Nonrational and Nonneutral System

$$X_t = Z_{t-1} \cdot g + u_t, \quad (2)$$

$$y_t = \tilde{y}_t + \sum_{i=0}^{n} c_i (X_{t-i} - Z_{t-i} \cdot g^*) + \sum_{i=0}^{n} d_i \cdot Z_{t-i} \cdot g^* + \varepsilon_t. \quad (6a)$$

The joint MRE hypothesis can be tested by comparing the system (I) and the system (IV). And the separate test of neutrality can be tested by comparing the system (I) and the system (II). On the other hand the test of rationality under the general assumption of nonneutrality can be tested by comparing the system (II) and the system (IV).

The likelihood ratio statistic is computed as

$$LR = 2(L^u - L^c),$$

where L^u is the value of the likelihood function for the unconstrained model and L^c is the value of the likelihood function when the constraints are imposed. This LR test statistic is distributed asymptotically as a chi-squared variable with degrees of freedom equal to the number of constraints.

III. Empirical Results

There is an excellent survey article by Okina (1986) about empirical studies on the validity of the MRE hypothesis as it applies to the Japanese economy. As for the application of Mishkin methodology to the Japanese case, there is an article by Gochoco (1986). Gochoco investigated the floating exchange rate period of 1973-84. Since the sample period was too short for the application of Mishkin methodology, Gochoco used monthly data. However, unlike Mishkin, Gochoco's lag specification is very short.[3]

For the empirical investigation of the high growth period, we have chosen the period from 1955 to 1973 for Japan from 1970 to 1988 for Korea.[4] For this period, economies of both countries went through remarkably rapid growth. Korean high growth started in the mid-sixties at a much lower level of per capita income compared with Japan and the rapid growth is still continuing and is expected to continue for some time at least. However, basic characteristics of the financial structure, which played an important role in the past, seems to be changing rapidly with the realization of the balance of payments surplus and the rapid development of the capital market in the recent period.

[3]Gochoco (1986) used monthly data to test MRE hypothesis for the period of 1973-84. Gochoco's lag specification for the monthly data is very short and could not possibly capture the usual long lag from the money growth to GNP. If one compares Gochoco's lag structure with most of the other author's lag specification, the limitation could be easily noticed. Besides, the sample period is too short for the useful test.

[4]In this paper, the unit root problem has not been explicitly dealt with. This is a common deficiency of most of the applications of Mishkin methodology.

In both countries, the government has used the allocation of money and credit under the artificially low rate of interest as a major policy tool in order to promote rapid growth of the strategic sector and economic growth in general. In the following subsections, we are going to apply Mishkin's methodology to the high growth period.[5]

A. The Case of Japan

The estimated models in the paper use seasonally adjusted, quarterly data over the period of 1955 and 1973. First, we have to specify the forecasting equation for the aggregate demand variable. In the analysis, we have experimented with various aggregate demand variables. For the Japanese case, we experimented with M2, M1, nominal GNP and GNP deflator. For the Korean case, we added domestic credit in addition to the above aggregate demand variables. In the main part of the paper, we will present the test results with M2 as the aggregate demand variable.

In the specification of the forecasting equation, we have used some kind of multivariate Granger criterion. The aggregate demand variable x_t, is regressed on its own four lagged values as well as four lagged values of a wide-ranging set of macroeconomic variables. The four lagged values of each of these variables are retained in the forecasting equation if they are jointly significant at the 5 percent level. The definitions of data, which are used in the experiments of the specification of the forecasting equation, are as follows.

M2G = growth rate of M2, calculated as the change in the log of quarterly M2
M1G = growth rate of M1
BLG = growth rate of total bank loan
CALLR = weighted average of call rates and bill rates
NGNPG = growth rate of nominal GNP
RGNP = real GNP
RGNPG = growth rate of real GNP
GDG = inflation rate, calculated as the change in the log of the GNP deflator
IPG = growth rate of industrial production index

[5]Korean high growth has started in the mid-1960's, and still is an ongoing process. However, we have chosen the sample period of 1970-88, owing to the problem of the continuity of time series data.

RGTXG = growth rate of real total government expenditure
RGCXG = growth rate of real governmnet consumption expenditures
NGTXG = growth rate of nominal total government expenditures
NGCXG = growth rate of nominal government consumption expenditures
NSUR = nominal current account surplus
RSUR = real surplus of the nation on current account

All the data come from the data base of the Bank of Japan. Table 1 reports *F*-statistics of the joint tests for the significance of explanatory power of the four lagged values of each variable in the list of potential explanatory variables. The estimated results for the forecasting equation of the model with 11 lag terms of unanticipated money growth is as follows.

$$\begin{aligned} M2G = {} & \underset{(1.64)}{0.009} + \underset{(3.29)}{0.73M2G_{t-1}} + \underset{(2.43)}{0.64M2G_{t-2}} + \underset{(1.28)}{0.29M2G_{t-3}} - \underset{(-3.97)}{0.85M2G_{t-4}} \\ & - \underset{(-3.61)}{0.33M1G_{t-1}} - \underset{(-1.91)}{0.21M1G_{t-2}} - \underset{(-3.20)}{0.31M1G_{t-3}} + \underset{(2.38)}{0.21M1G_{t-4}} \\ & + \underset{(0.59)}{0.02NGCXG_{t-1}} + \underset{(3.93)}{0.12NGCXG_{t-2}} + \underset{(2.41)}{0.08NGCXG_{t-3}} + \underset{(1.09)}{0.03NGCXG_{t-4}} \\ & + \underset{(2.89)}{0.38BLG_{t-1}} - \underset{(-0.72)}{0.11BLG_{t-2}} + \underset{(2.42)}{0.37BLG_{t-3}} - \underset{(-1.74)}{0.21BLG_{t-4}} \end{aligned}$$

$R^2 = 0.7142$
$SE = 0.0045$
$D - W = 1.99$

Before reporting the main results, the problem of the specification of the lag length in the output equation needs to be mentioned. Earlier research by Barro (1977), Barro and Rush (1980), and Leiderman (1980) on the MRE hypothesis has used two-year lags of the unanticipated and anticipated aggregate demand variable at the most. Their results were favorable to the MRE hypothesis. Mishkin (1981), with his improved test methods, concentrated on the longer lags, i.e., 5-year lags of the unanticipated and anticipated aggregate demand variable. Mishkin justified his specification of longer lags on two grounds. First, Mishkin claims that experimenting with plausible, less restrictive models that have longer lag lengths is an appropriate strategy for analyzing the robustness of results. Second, Mishkin found that the unanticipated aggregate demand variables lagged as far back as 20 quarters are

TABLE 1
SELECTION OF VARIABLES FOR FORECASTING EQUATION FOR JAPAN

Variables	*M2G* Forecasting Equation	Nominal GNP Forecasting Equation
	F-Statistics	*F*-Statistics
M2G	10.62**	0.86
M1G	2.66*	1.55
BLG	3.08*	0.75
CALLR	1.02	3.43*
NGNPG	0.60	0.19
RGNPG	0.71	1.65
GDG	0.53	1.65
IPG	0.43	2.90*
RGTXG	0.51	0.51
RGCXG	1.55	2.78*
NGTXG	0.57	4.79**
NGCXG	5.97**	1.14
NSUR	1.39	1.28
RSUR	1.68	0.62

Note: In the forecasting equations, four lagged values of each variable were investigated as explanatory variables, together with the dependent variable's own four lagged terms. The *F*-statistics test the null hypothesis that the sum of the coefficients on the four lagged values of each of these variables is equal to zero.
* : Significant at the 5 percent level.
**: Significant at the 1 percent level.

significantly correlated with output.

In this paper, we are presenting the main results with three-year lag specification, using the results for the two-year lag specification as supplementary evidence. Even if we accept partly the Mishkin's point that experiments with longer lags are necessary, we have some reservations for Mishkin's lag specification. First, if one specifies the lag length which exceeds the one-cycle period of the reference business cycle, there can be serious misspecification problem. It may possibly capture the spurious effect of the one-cycle earlier aggregate demand policy on the current output. Second, specification of too long lags can have a serious shortcoming for the small sample, since the number of parameters that have to be estimated in Mishkin-type model are very large compared with the sample period.

We have chosen the three-year lag length as a pragmatic compromise, considering the above-mentioned points together with the conjec-

TABLE 2

ESTIMATED M2G FORECASTING EQUATION FOR JAPAN

	Model with 11 Lag Terms of Unanticipated Money Growth	Model with' 11 Lag Terms of Unanticipated and Anticipated Money Growth	Model with 7 Lag Terms of Unanticipated Money Growth	Model with 7 Lag Terms of Unanticipated and Anticipated Money Growth	OLS Estimates
Constant	0.009 (1.64)	-0.004 (-0.82)	0.005 (0.73)	0.01 (2.58)	-0.001 (-0.16)
$M2G_{t-1}$	0.73 (3.29)	0.92 (7.89)	0.70 (2.97)	0.62 (4.87)	0.66 (2.55)
$M2G_{t-2}$	0.64 (2.43)	0.61 (4.42)	0.68 (2.51)	0.78 (4.87)	0.88 (3.10)
$M2G_{t-3}$	0.29 (1.28)	0.44 (4.01)	0.002 (0.01)	-0.23 (-1.87)	0.11 (0.39)
$M2G_{t-4}$	-0.85 (-3.97)	-0.33 (-2.74)	-0.32 (-1.45)	-0.46 (-3.71)	-0.15 (-0.65)
$M1G_{t-1}$	-0.33 (-3.61)	-0.28 (-5.86)	-0.39 (-3.98)	-0.26 (-4.37)	-0.24 (-2.38)
$M1G_{t-2}$	-0.21 (-1.91)	-0.32 (-6.77)	-0.28 (-2.40)	-0.32 (-5.25)	-0.31 (-2.67)
$M1G_{t-3}$	-0.31 (-3.20)	-0.28 (-6.51)	-0.12 (-1.24)	-0.05 (-1.00)	-0.09 (-0.80)
$M1G_{t-4}$	0.21 (2.38)	-0.02 (-0.57)	-0.10 (-0.15)	0.10 (2.27)	-0.06 (-0.72)
$NGCXG_{t-1}$	0.02 (0.59)	0.04 (2.58)	0.02 (0.53)	-0.02 (-1.21)	0.07 (1.96)
$NGCXG_{t-2}$	0.12 (3.93)	0.13 (5.77)	0.13 (3.89)	0.06 (2.31)	0.13 (3.44)
$NGCXG_{t-3}$	0.08 (2.41)	0.15 (6.09)	0.16 (4.46)	0.09 (3.66)	0.19 (5.18)
$NGCXG_{t-4}$	0.03 (1.09)	0.10 (5.90)	0.07 (02.16)	0.03 (1.88)	0.12 (3.46)
BLG_{t-1}	0.38 (2.89)	-0.01 (-0.24)	0.29 (1.93)	0.17 (2.71)	0.15 (0.95)
BLG_{t-2}	-0.11 (-0.72)	0.07 (1.36)	0.15 (0.91)	0.22 (3.45)	-0.06 (-0.33)
BLG_{t-3}	0.37 (2.42)	0.06 (1.13)	0.21 (1.30)	0.14 (2.27)	0.04 (0.28)
BLG_{t-4}	-0.21 (-1.74)	-0.10 (-2.11)	-0.31 (-2.35)	-0.14 (-2.76)	-0.34 (-2.48)
R^2	0.7142	0.7193	0.6661	0.6142	0.6991
SE	0.0045	0.0045	0.0048	0.0052	0.0054
D-W	1.99	2.09	1.76	1.91	1.98

Note: Forecasting equations were estimated with the output equation, imposing the corss-equation constraints that g is equal in both equations. For purposes of comparison, OLS column show the OLS estimates of the unconstrained forecasting equation.

TABLE 3

LIKELIHOOD RATIO TESTS OF THE MRE HYPOTHESIS FOR JAPAN WITH M2 GROWTH AS THE AGGREGATE DEMAND VARIABLE

	Log (GNP_t) with 11 Lags of ($M2G_t$–$M2G_t^e$)	Log (GNP_t) with 7 Lags of ($M2G_t$–$M2G_t^e$)
Joint Hypothesis		
Likelihood Ratio Statistic	χ^2 (27) = 50.12**	χ^2 (23) = 40.77*
Marginal Significance Level	0.004	0.014
Neutrality		
Likelihood Ratio Statistic	χ^2 (12) = 32.04**	χ^2 (8) = 30.98**
Marginal Significance Level	0.001	0.001
Rationality		
Likelihood Ratio Statistic	χ^2 (15) = 18.08	χ^2 (15) = 9.79
Marginal Significance Level	0.261	0.825

Note: Marginal significance level is equal to the probability of getting that value of the likelihood ratio statistic or higher under the null hypothesis.
* : Significant at the 5 percent level.
**: Significant at the 1 percent level.

ture that the adjustment speed of the economy would be faster for the high growth period.

Table 3 summarizes the major findings by presenting the likelihood ratio tests of the MRE hypothesis with M2 growth as the aggregate demand variable. The joint hypothesis of neutrality and rationality is rejected both for three-year lag case and for two-year lag case. For the two-year lag case the joint hypothesis rejected at the 5 percent level of significance. On the other hand, for the three-year lag case, it is more strongly rejected at the 1 percent level of significance.

Separate tests of the neutrality and rationality given more interesting result. For both lag specification, the rational expectation hypothesis is not rejected, while the neutrality proposition is strongly rejected for both specification. Judging from the overall results, rational expectations hypothesis seems to be a useful hypothesis, which can be applied to the analysis of the high growth period.

Table 4 reports output equation jointly estimated with the forecasting equation, imposing the cross-equation rationality constraints. It is estimated results of the system (I). As one can see in Table 4, unanticipated money growth variables have significantly positive effect on real GNP. For the 3-year lag case, the effects of unanticipated M2 growth

TABLE 4
NONLINEAR ESTIMATES OF OUTPUT EQUATIONS FOR JAPAN
EXPLANATORY VARIABLES: UNANTICIPATED MONEY GROWTH

$$y_t = a + b \ \text{Time} + \sum_{i=0}^{n} c_i (M2G_{t-1} - M2G^e_{t-1}) + \rho\varepsilon_{t-1} + \eta_t$$

Log (GNP_t) with 11 Lags of ($M2G_t$-$M2G^e_t$)	Log (GNP_t) with 7 Lags of ($M2G_t$-$M2G^e_t$)
a = 10.44 (267.19)	a = 10.40 (274.13)
b = 0.02 (30.97)	b = 0.02 (31.76)
c_0 = 2.17 (6.35)	c_0 = 0.88 (2.58)
c_1 = 1.58 (3.37)	c_1 = 0.93 (2.27)
c_2 = 1.28 (2.47)	c_2 = 0.48 (1.13)
c_3 = 1.00 (2.20)	c_3 = 0.46 (1.10)
c_4 = 0.56 (1.38)	c_4 = -0.13 (-0.32)
c_5 = 1.48 (3.67)	c_5 = 1.16 (2.83)
c_6 = 1.67 (4.05)	c_6 = 1.07 (2.77)
c_7 = 1.48 (3.58)	c_7 = 0.62 (1.86)
c_8 = 0.55 (1.29)	
c_9 = -0.03 (-0.07)	
c_{10} = -0.20 (-0.52)	
c_{11} = -0.50 (-1.91)	
ρ = 0.91 (20.50)	ρ = 0.91 (17.69)
R^2 = 0.9980	R^2 = 0.9989
SE = 0.0171	SE = 0.0137
$D-W$ = 1.81	$D-W$ = 2.01

Note: Estimated from the equation (2) and (4) system, imposing the cross-equation constraints that g is equal in equation (2) and (4). T-statistics are in parentheses.

are larger and more significant, compared with the case of the 2-year lag specification. The sun of the coefficients of unanticipated M2 growth for the 3-year lag case is 11.04, while the sum for 2-year lag case is 5.47. It is interesting that the pattern of parameter estimates is very similar to each other.

Table 5 reports output equation with both unanticipated and anticipated M2 growth as explanatory variables. The equation 6 is jointly estimated with equation 2, imposing the cross-equation rationality constraint. The unanticipated M2 growth has strong and positive effect. The pattern of the coefficients are rather similar to the pattern of the estimates of the system (I). On the other hand, the effect of anticipated

TABLE 5
NONLINEAR ESTIMATES OF OUTPUT EQUATIONS FOR JAPAN
EXPLANATORY VARIABLES: UNANTICIPATED AND ANTICIPATED MONEY GROWTH

$$y_t = a + b \ \text{Time} + \sum_{i=0}^{n} c_i (M2G_{t-1} - M2G^e_{t-1}) + \sum_{i=0}^{n} d_i M2G^e_{t-1} + \rho\varepsilon_{t-1} + \eta_t$$

Log(GNP$_t$) with 11 Lags of ($M2G_t$-$M2G^e_t$)		Log(GNP$_t$) with 7 Lags of ($M2G_t$-$M2G^e_t$)	
a = 10.49 (95.60)		a = 10.29 (111.70)	
b = 0.02 (25.43)		b = 0.02 (18.58)	
c_0 = 2.67 (7.78)	d_0 = -1.33 (-1.89)	c_0 = 1.78 (6.12)	d_0 = 1.27 (2.05)
c_1 = 2.96 (5.83)	d_1 = 2.04 (1.76)	c_1 = 1.09 (2.93)	d_1 = -1.48 (-1.59)
c_2 = 2.11 (3.58)	d_2 = -0.93 (-0.74)	c_2 = 1.23 (3.04)	d_2 = 2.56 (2.39)
c_3 = 2.34 (4.07)	d_3 = -0.54 (-0.49)	c_3 = 1.02 (2.36)	d_3 = -1.02 (-1.03)
c_4 = 1.63 (3.00)	d_4 = 3.59 (3.02)	c_4 = 0.19 (0.48)	d_4 = 3.71 (3.07)
c_5 = 1.55 (2.40)	d_5 = -4.01 (-2.91)	c_5 = 0.67 (1.28)	d_5 = -3.71 (-2.65)
c_6 = 2.60 (2.99)	d_6 = 0.97 (0.77)	c_6 = 1.09 (1.07)	d_6 = 2.41 (2.16)
c_7 = 0.37 (0.47)	d_7 = 2.23 (1.96)	c_7 = 1.96 (3.35)	d_7 = -0.62(-0.80)
c_8 = -0.17 (-0.25)	d_8 = -2.72 (-2.49)		
c_9 = -0.96 (-1.52)	d_9 = 0.29 (0.31)		
c_{10} = -0.25 (-0.40)	d_{10} = -0.47 (-0.61)		
c_{11} = 1.16 (1.97)	d_{11} = -0.90 (-1.52)		
ρ = 0.94 (26.26)		ρ = 0.96 (28.95)	
R^2 = 0.9987		R^2 = 0.9988	
SE = 0.0138		SE = 0.0145	
$D-W$ = 2.03		$D-W$ = 1.86	

Note: Estimated from the equation (2) and (6) system, imposing the restriction, that g is equal in equation (2) and (6).

M2 growth has an extremely irregular pattern. It has a zig-zag pattern with the alternately positive and negative coefficient. The sum of the coefficients of the anticipated money growth for the 3-year lag case is relatively small and negligible, and the sign is negative. For the 2-year lag case, it also has a zig-zag pattern and the sum of the coefficients are relatively small. However, the sign is positive contrary to the case of the 3-year lag. Even if the neutrality proposition is rejected for both cases, the overall effect of anticipated M2 growth on the output seems to be negligible. Statistically, the zig-zag pattern of coefficients of anticipated M2 growth seems to increase the fitting of the equations, thereby leading to the rejection of neutrality hypothesis. However, it is hard to interpret the pattern in a economically meaningful way. Anyway, the

TABLE 6
SELECTION OF VARIABLES FOR FORECASTING EQUATIONS FOR KOREA

Variables	*M2G* Forecasting Equation	Nominal GNP Forecasting Equation
	F-Statistics	*F*-Statistics
M2G	25.71**	1.38
M1G	0.99	3.69**
DCG	0.59	1.80
BLG	0.94	0.71
NGNPG	0.19	2.62*
RGNPG	0.78	1.13
GDG	1.40	1.13
IPG	0.68	1.11
RGCXG	1.97	0.59
NGCXG	1.11	0.38
NGTXG	2.21	0.59
NGSUR	0.31	4.33*
NSUR	0.98	0.90
RSUR	0.71	0.04
FXHG	0.72	1.00

Note: In the forecasting equations, four lagged values of each variable were investigated as explanatory variables, together with the dependent variable's own four lagged terms. The *F*-statistics test the null hypothesis that the sum of the coefficients on the four lagged values of each of these variables is equal to zero.
* : Significant at the 5 percent level.
**: Significant at the 1 percent level.

sum of the coefficients are negligibly small.

B. The Case of Korea

The data used for the analysis of the Korean case are almost the same as the Japanese case, except the following few differences. Since the weighted average of call rates and bill rates is not available for the sample period, we dropped it out from the list of potential candidate variables in the specification of the forecasting equation. On the other hand, we have added *NGSUR* and *FXHG* in the list. *NGSUR* is nominal government surplus, and *FXHG* is gold and foreign exchange holdings.

We have applied the same kind of multivariable Granger criterion in the specification of the forecasting equation. The results for the selection of variables of the forecasting equations are reported in Table 6.

TABLE 7

ESTIMATED M2G FORECASTING EQUATION FOR KOREA

	Model with 11 Lag Terms of Unanticipated Money Growth	Model with 11 Lag Terms of Unanticipated and Anticipated Money Growth	Model with 7 Lag Terms of Unanticipated Money Growth	Model with7 Lag Terms of Unanticipated and Anticipated Money Growth	OLS Estimates
Constant	0.008 (1.90)	0.007 (1.34)	0.007 (1.48)	0.007 (1.46)	0.009 (1.74)
$M2G_{t-1}$	0.77 (5.80)	0.67 (5.15)	0.73 (5.76)	0.73 (5.73)	0.84(6.37)
$M2G_{t-2}$	-0.23 (-1.52)	-0.07 (-0.47)	-0.14 (-0.90)	–0.13 (-0.83)	-0.25 (-1.57)
$M2G_{t-3}$	0.24 (1.71)	0.27 (2.15)	0.15 (0.96)	0.17 (1.11)	0.25 (1.61)
$M2G_{t-4}$	-0.03 (-0.27)	-0.02 (-0.16)	0.07 (0.58)	0.06 (0.52)	-0.08 (-0.65)
$NGTXG_{t-1}$	0.01 (0.57)	-0.01 (-0.96)	0.002 (0.15)	–0.01 (-0.89)	0.02 (1.07)
$NGTXG_{t-2}$	0.01 (0.95)	-0.004 (-0.76)	0.01 (0.65)	0.004 (0.41)	0.02 (1.27)
$NGTXG_{t-3}$	0.04 (2.85)	0.01 (1.02)	0.04 (2.41)	0.03 (2.04)	0.04 (2.42)
$NGTXG_{t-4}$	0.02 (1.34)	0.01 (0.96)	0.01 (0.87)	0.003(0.25)	0.01 (0.39)
R^2	0.6664	0.6529	0.6614	0.6551	0.6848
SE	0.0112	0.0114	0.0110	0.0111	0.0120
$D-W$	2.26	1.98	2.08	2.02	2.07

Note: Forecasting equations were estimated with the output equation, imposing the cross-equation constraints that g is equal in both equations. For purposes of comparison, OLS column shows the OLS estimates of the unconstrained forecasting equation.

TABLE 8
LIKELIHOOD RATIO TESTS OF THE MRE HYPOTHESIS FOR KOREA WITH M2 GROWTH AS THE AGGREGATE DEMAND VARIABLE

	Log (GNP$_t$) with 11 Lags of ($M2G_t$-$M2G_t^e$)	Log (GNP$_t$) with 7 Lags of ($M2G_t$-$M2G_t^e$)
Joint Hypothesis		
Likelihood Ratio Statistic	χ^2 (19) = 14.95	χ^2 (19) = 8.77
Marginal Significance Level	0.724	0.977
Neutrality		
Likelihood Ratio Statistic	χ^2 (12) = 14.84	χ^2 (8) =6.44
Marginal Significance Level	0.250	0.599
Rationality		
Likelihood Ratio Statistic	χ^2 (7) = 0.11	χ^2 (11) = 2.33
Marginal Significance Level	0.999	0.998

Note: Marginal significance level is equal to the probability of getting that value of the likelihood ration statistic or higher under the null hypothesis.
* : Significant at the 5 percent level.
**: Significant at the 1 percent level.

Comparing the results with those for Japan, one major difference is that usually smaller number of variables is significant in both the M2 growth forecasting equation and the nominal GNP forecasting equation. It seems that more elaborate relationships exist among variables of the forecasting equation for the case of Japan. In the M2 growth forecasting equation we included nominal total government expenditure growth, even though it was slightly less significant. In the selection of variables, we followed, as a practical compromise, a rule to include as a minimum one more variable besides the dependent variable's own lagged terms, and to include the maximum of three other variables.

The estimated *M2G* forecasting equation of the model with 11 lag terms of unanticipated money growth is as follows:

$$\underset{(1.90)}{M2G=0.008} + \underset{(5.80)}{0.77M2G_{t-1}} - \underset{(-1.52)}{0.23M2G_{t-2}} + \underset{(1.71)}{0.24M2G_{t-3}} - \underset{(-0.27)}{0.03M2G_{t-4}}$$

$$+ \underset{(0.57)}{0.01NGCXG_{t-1}} + \underset{(0.95)}{0.11NGCXG_{t-2}} + \underset{(2.85)}{0.04NGCXG_{t-3}} + \underset{(1.34)}{0.02NGCXG_{t-4}}$$

$R^2 = 0.6664$
$SE = 0.0112$
$D-W = 2.26$

TABLE 9

LIKELIHOOD RATIO TEST OF THE RATIONAL EXPECTATIONS HYPOTHESIS UNDER THE ASSUMPTION OF NEUTRALITY WITH M2 GROWTH FOR KOREA

	Log (GNP_t) with 11 Lags of ($M2G_t$-$M2G_t^e$)	Log (GNP_t) with 7 Lags of ($M2G_t$-$M2G_t^e$)
Rationality Test		
Likelihood Ratio Statistic	χ^2 (9) = 13.94	χ^2 (9) = 9.62
Marginal Significance Level	0.134	0.395

Note: Marginal significance level is equal to the probability of getting that value of the likelihood ratio statistic or higher under the null hypothesis.
* : Significant at the 5 percent level.
**: Significant at the 1 percent level.

Table 8 summarizes the main findings by presenting the likelihood ratio tests of the MRE hypothesis with M2 growth as the aggregate demand variable. The joint hypothesis of neutrality is not rejected both for the 3-year lag specification and for the 2-year lag specification. MRE hypothesis seems to be applicable to the high growth period for Korea. Separate tests of the neutrality and the rationality gives the following results. For both lag specifications, the rational expectation hypothesis seems to be supported strongly. As for the neutrality proposition, it is not rejected by test statistics. However, the marginal significance level seems to decrease somewhat for the 3-year lag specification.

In the test already reported, the rational expectations hypothesis was tested comparing the system (II) and the system (IV). That is, the rational expectation hypothesis was tested without imposing the neutrality proposition. Since the neutrality proposition is not rejected, we applied another test of rational expectations hypothesis. In the new test we tested the rational expectation hypothesis under the assumption that the neutrality proposition holds. For this purpose we compared the system (I) and the system (III). The test results are reported in the Table 9. For both 3-year and 2-year lag specifications, rational expectations hypothesis are strongly supported. The marginal significance level is as high as 99.9 and 99.5 percent respectively.

The estimates of output equations with unanticipated M2 growth as explanatory variables, jointly estimated with the equation 2, are reported in Table 10. The unanticipated M2 growth variable has an overall positive effect on output, for the 3-year lag specification. However, the lag structure of coefficients has a peculiarity. At the short lag, the effect

TABLE 10
NONLINEAR ESTIMATES OF OUTPUT EQUATIONS FOR KOREA
EXPLANATORY VARIABLES: UNANTICIPATED MONEY GROWTH

$$y_t = a + b \text{ Time} + \sum_{i=0}^{n} c_i (M2G_{t-1} - M2G^e_{t-1}) + \rho\varepsilon_{t-1} + \eta_t$$

Log (GNP$_t$) with 11 Lags of ($M2G_t$-$M2G^e_t$)	Log (GNP$_t$) with 7 Lags of ($M2G_t$-$M2G^e_t$)
a = 8.43 (139.72)	a = 8.42 (86.89)
b = 0.02 (15.41)	b = 0.02 (10.70)
c_0 = -1.26 (-3.45)	c_0 = -2.39 (-7.55)
c_1 = -0.15 (-0.29)	c_1 = -1.23 (-2.97)
c_2 = -0.41 (-0.69)	c_2 = -1.36 (-2.83)
c_3 = -0.43 (-0.71)	c_3 = -0.80 (-1.59)
c_4 = 0.23 (0.39)	c_4 = -0.35 (-0.72)
c_5 = 0.91 (1.55)	c_5 = 0.31 (0.67)
c_6 = 1.26 (2.08)	c_6 = 0.54 (1.34)
c_7 = 1.15 (1.80)	c_7 = 0.41 (1.31)
c_8 = 0.68 (1.04)	
c_9 = 0.38 (0.63)	
c_{10} = 0.11 (0.21)	
c_{11} = -0.60 (-1.58)	
ρ = 0.88 (13.78)	ρ = 0.88 (15.91)
R^2 = 0.9925	R^2 = 0.9898
SE = 0.0255	SE = 0.0324
$D-W$ = 2.25	$D-W$ = 2.28

Note: Estimated from the equation (2) and (4) system, imposing the cross-equation constraints that g is equal in equation (2) and (4). T-statistics are in parentheses.

on output are negative. However, the sign of the coefficients turns positive after 3 quarters. And the overall effect is positive.

Table 11 reports the output equation with both the unanticipated and anticipated M2 growth. For the three lag specification, the pattern of coefficients for the unanticipated M2 growth is similar to the pattern of Table 10. The coefficients of the anticipated M2 growth are positive for short lags, while they turn negative for longer lags. Overall they have slightly positive effects, and generally speaking, coefficients are much less significant. That may be the reason why the neutrality proposition is not rejected.

TABLE 11
NONLINEAR ESTIMATES OF OUTPUT EQUATIONS FOR KOREA
EXPLANATORY VARIABLES: UNANTICIPATED AND ANTICIPATED MONEY GROWTH

$$y_t = a + b \text{ Time} + \sum_{i=0}^{n} c_i(M2G_{t-1} - M2G^e_{t-1}) + \sum_{i=0}^{n} d_i M2G^e_{t-1} + \rho\varepsilon_{t-1} + \eta_t$$

Log(GNP_t) with 11 Lags of ($M2G_t$-$M2G^e_t$)		Log(GNP_t) with 7 Lags of ($M2G_t$-$M2G^e_t$)	
a = 8.26 (28.61)		a = 8.03 (33.90)	
b = 0.02 (9.38)		b = 0.02 (10.49)	
c_0 = -0.76 (-1.85)	d_0 = 7.05 (0.94)	c_0 = -0.87 (-2.48)	d_0 = 2.24 (1.36)
c_1 = -4.28 (-0.82)	d_1 = 1.52 (0.25)	c_1 = -1.51 (-1.15)	d_1 = 3.11 (1.48)
c_2 = -3.82 (-0.85)	d_2 = 3.54 (0.53)	c_2 = -3.44 (-1.54)	d_2 = 2.13 (1.10)
c_3 = -6.00 (-0.96)	d_3 = -5.77 (-0.57)	c_3 = -3.40 (-1.18)	d_3 = 0.94 (0.70)
c_4 = -0.42 (-0.08)	d_4 = -1.36 (-0.17)	c_4 = -3.06 (-1.05)	d_4 = 0.06 (0.05)
c_5 = -0.75 (-0.18)	d_5 = -6.28 (-0.65)	c_5 = -2.13 (-0.90)	d_5 = -1.49 (-0.90)
c_6 = 4.44 (0.75)	d_6 = -0.59 (-0.08)	c_6 = -0.50 (-0.33)	d_6 = -0.79 (-0.51)
c_7 = 3.83 (0.90)	d_7 = -2.19 (-0.31)	c_7 = -0.01 (-0.01)	d_7 = -0.57 (-0.51)
c_8 = 5.18 (0.92)	d_8 = 1.23 (0.18)		
c_9 = 3.44 (0.98)	d_9 = 0.94 (0.20)		
c_{10} = 2.76 (0.80)	d_{10} = -0.12 (-0.03)		
c_{11} = 2.42 (1.21)	d_{11} = 3.64 (1.55)		
ρ = 0.91 (14.40)		ρ = 0.88 (13.37)	
R^2 = 0.9953		R^2 = 0.9947	
SE = 0.0202		SE = 0.0231	
$D-W$ = 2.33		$D-W$ = 2.52	

Note: Estimated from the equation (2) and (6) system, imposing the restriction, that g is equal in equation (2) and (6)

IV. Conclusion

In this paper, we have investigated the joint MRE hypothesis for the high growth period of Japan and Korea. The joint MRE hypothesis of neutrality and rationality is rejected in the case of Japan for the high growth period. Separate tests of neutrality and rationality show that non-neutrality is the main reason for the rejection of the joint MRE hypothesis. However, rational expectation hypothesis is not rejected for the high growth period. In contrast to the case of Japan, the joint hypothesis is not rejected for Korea. Both the neutrality proposition and the rational expectation hypothesis is supported. Even though the test results show contrasting results for the joint hypothesis of neutrality and rationality for two countries, separate tests of neutrality and rationality show that rational expectation hypothesis is not rejected for both countries.

One of the major findings of the paper is that rational expectations hypothesis is not rejected even under the rapidly changing circumstances of high economic growth. These results support the modeling strategies in which expectations are assumed to be rational. The other finding is less positive. We have to be careful about the interpretation of the policy neutrality proposition. The fact that we have contrasting results for the neutrality proposition for Japan and Korea may be an indirect evidence of the unimportance of the real effect of the expected overall growth of money supply. As we have already noticed, the total effect of the anticipated M2 on real output has been very small at the most.

Mishkin methodology and most of the other methods that have been used to test the joint MRE hypothesis are not capable of capturing the allocative effect of the monetary policy. It seems that we needs a methodological innovation which can handle the effect of sectoral allocation of money and credit in order to test the effect of monetary policy in the general setting.

(Received December, 1995; Revised March, 1997)

References

Abel, Andrew, and Mishkin, Frederic, S. "An Integrated View of Tests of Rationality, Market Efficiency and the Short-Run Neutrality of Monetary Policy." *Journal of Monetary Economics* 11 (1983): 3-24.

Barro, Robert. "Unanticipated Money Growth and Unemployment in the United States." *American Economic Review* 67 (March 1977): 101-15.

____________. "Unanticipated Money, Output and the Price Level in the United States." *Journal of Political Economy* 86 (August 1978): 549-80.

____________. "Unanticipated Money Growth and Unemployment in the United States: Reply." *American Economic Review* 69 (December 1979): 1004-9.

____________, and Rush, Mark. "Unanticipated Money and Economic Activitiy." In Stanley Fishcer, ed., *Rational Expectations and Economic Policy*, Chicago: University of Chicago Press 1980, 23-48.

Cechetti, Stephen G. "Testing Short-run Neutrality." *Journal of Monetary Economics* 17 (May 1980): 409-23.

Chopra, Ajai, and Montiel, Peter. "Output and Unanticipated Money with

Imported Intermediate Goods and Foreign Exchange Rationing." Staff Papers, International Monetary Fund (December 1986): 697-721.

Gochoco, Maria S. "Tests of the Macro Rational Expectations Hypothesis: The Case of Japan 1973-1984." *Journal of Money, Credit and Banking* (November 1986): 459-66.

Gordon, Robert J. "Price Inertia and Policy Ineffectiveness in the United States, 1890-1980." *Journal of Political Economy* 90 (1982): 1087-117.

Grossman, Jacob. "Nominal Demand Policy and Short-Run Fluctuations in Unemployment and Prices in the United States." *Journal of Political Economy* 87 (October 1979): 1063-85.

Granger, Clive W.J. "Investigating Causal Relations by Econometric Models and Cross-Sepectral Methods." *Econometrica* 37 (July 1969): 424-38.

Hamada, Koichi, and Horuchi, Akiyoshi. "The Political Economy of the Financial Market." in Yamamura, Kozo and Yasuba, Yasukichi, ed., *The Political Economy of Japan* Vol I, *The Domestic Transformation*, Stanford University Press: Stanford, 1987: 223-60.

Komura, Chikara. "Money, Income, and Causality: The Japanese Case." *Southern Economic Journal* (July 1982): 19-34.

Lee, Kye-Sik. "Rational and Non-Rational Expectations of Inflation in Korea." Korea Development Institute, Working Paper 8309, 1983.

Leiderman, Leonardo. "Macroeconometric Testing of the Rational Expectations and Structural Neutrality Hypothesis for the United States." *Journal of Monetary Economics* 6 (January 1986): 69-82.

McGee, Robert T., and Stasiak, R.T. "Does Anticipated Monetary Policy Matter? Another Look." *Journal of Money, Credit and Banking* (February 1985): 16-27.

Meltzer, Allan H. "Variability of Prices, Output and Money Under Fixed and Fluctuating Exchange Rates: An Empirical Study of Monetary Regimes in Japan." *Monetary and Economic Studies* 3 (December 1985).

Mishkin, Frederic S. "Does Anticipated Monetary Policy Matter? An Econometric Investigation." *Journal of Political Economy* 90 (February 1982): 22-51.

____________. "Does Anticipated Monetary Policy Matter? Further Econometric Results." *American Economic Review* 72 (1982b): 788-802.

____________. *A Rational Expectations Approach to Macroeconomics: Testing Policy Ineffectiveness and Efficient Markets Models.* Chicago: University of Chicago Press, 1983.

Nelson, Charles R. "Granger Causality and the Natural Rate Hypothesis." *Journal of Political Economy* 87 (April 1879): 309-94.

Okina, Kunio. "Reexamination of Empirical Studies Using Granger-'Causality' Between Money Supply and Nominal Income." *Monetary and Economic Studies* 3, No.3, Institute for Monetary and Economic Studies, Bank of Japan (December 1985): 129-62.

____________. "Relationship between Money Stock and Real Output in the Japanese Economy-Survey on the Empirical Tests of the LSW Proposition." *Monetary and Economic Studies* 4, No.1, Institute for Monetary and Economic Studies, Bank of Japan (April 1986): 41-77.

Park, Yung Chul. *Financial Development of Korea*. Korea Development Institute, 1984.

Parkin, Michael. "Discriminating between Keynesian and Classical Theories of the Business Cycle: Japan 1967-1982." *Monetary and Economic Studies* (December 1984): 23-60.

Pesaran, M.H. "On the Policy Ineffectiveness Proposition and a Keynesian Alternative: A Rejoinder." *Economic Journal* (June 1988): 504-8.

Piggot, C. "Rational Expectations and Counter-cyclical Monetary Policy: The Japanese Experience." *Federal Reserve Bank of San Francisco Economic Review* (Summer 1978).

Ram, Rati. "Money, Income and Causality in Japan—Supplementary Evidence: Comment." *Southern Economic Journal* (April 1984): 1214-8.

Rush, Mark, and Waldo, Douglas. "On the Policy Ineffectiveness Proposition and a Keynesian Alternative." *The Economic Journal* (June 1988): 498-503.

Sargent, Thomas, J. "A Classical Macroeconomic Model for the United States." *Journal of Political Economy* 84 (April 1976): 207-37.

__________. "The Observational Equivalence of Natural and Unnatural Rate Theories of Macroeconomics," *Journal of Political Economy* 84 (June 1976): 631-40.

__________. *Rational Expectations and Inflation*. New York: Harper & Row, 1986.

Seo, Junichiro, and Takahashi, Wataru. "Anticipated Money and Real Output: An An Examination of the Macro Rational Expectations Hypothesis of Japan." Discussion Paper Series, No.10, Bank of Japan, November 1981.

Sims, Christopher A. "Money, Income, and Causality." *American Economic Review* 62 (1972): 540-52.

Suzuki, Yoshio. *Money and Banking in Contemporary Japan*. New Haven and London: Yale University Press, 1980.

Thornton, Daniel L., and Batten, Dallas S. "Lag-Length Selection and Tests of Granger Causality between Money and Income." *Journal of Money, Credit and Banking* 17 (May 1985): 164-78.