Relationship between Money Stock and Real Output in the Japanese Economy — Survey on the Empirical Tests of the LSW Proposition*

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I. Introduction

The relation between money stock and income has always been one of the key points at issue in the dispute between Keynesians and non-Keynesians.

There are two main trends in the development since the 1970s of empirical studies in the monetarist tradition. The first type utilizes Granger Causality to analize mainly the relation between money stock and nominal income. This type of empirical study can be interpreted as an extension of studies carried out by Friedman and Schwartz (1963). In that sense, it is a development in line with the orthodox monetarist. The methods which have exerted the greatest influence are developed in Sims (1972) and (1980).[1]

The second type of study attempts to verify the empirical validity of the proposition advanced by Lucas, Sargent, and Wallace: that anticipated fluctuations in the money stock do not have any influence on actual economic activities, even in the short run. This — hereinafter, the LSW proposition — is in line with rational expectation wing of the monetarist school. Specifically, the first development of the empir-

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1. See Okina (1985) for a detailed overview of this line of studies of Japanese economy.

ical method was achieved by Barro (1977). Since then, various criticisms and suggestions have been made from the viewpoint of both economic theory and econometric method by Small (1979), Leiderman (1980), Fischer (1980), Mishkin (1983), etc.

This paper attempts to survey the development of empirical studies on the validity of the LSW proposition as it applies to the Japanese economy.

First, we will survey studies that, essentially, adopt Barro's method. Studies along this line have been done by Pigott (1978) and Seo and Takahashi (1981).

Real output is generally dependent on various factors. Even if real output is the function only of "unanticipated price fluctuations", these are dependent not only on "unanticipated fluctuations in the money stock" but also on "unanticipated fluctuations in other variables". However, since variables other than unanticipated errors in the money stock are left out of the list of independent variables used in the Barro-type tests, these factors may produce bias. Some of the results obtained by Hamada and Hayashi (1985) can be regarded as taking this point into consideration.

The second criticism is the standpoint, exposed by Fischer (1980) and others, that attatches importance to nominal wage rigidity: if a labor contract is in effect for a long period of time, wages will be rigid for that duration, and the LSW proposition would not hold. As far as the Japanese economy is concerned, the important question is whether to regard nominal wage levels as being unchanged from the time they are determined at the time of one year's "Shunto", the annual spring wage negotiation, until the next Shunto, or as being flexible as a result of changes in the size of bonuses and overtime allowances. Taniuchi (1982) centered on this point.

Thirdly, Parkin (1984) claims the importance of seasonality and trends in testing the LSW proposition. After demonstrating that the treatment of seasonality and trend have a significant influence on his empirical results, Parkin insists that the Classical model (including the LSW proposition) is more capable of explaining the Japanese economy than the "Keynesian" model provided the moving average type of seasonal adjustment often used in the earlier studies is properly modified. Here, in addition to introducing the points at issue, we will indicate some reservations about Parkin's findings.

The fourth critique emphasizes that while Barro assumes rational expectations, his empirical study fails to fully exploit the cross equation restriction between money supply equation and the output equation. A new empirical methodology was developed from this standpoint by Mishkin through his series of studies. We will take up Gochoco (1986) as an empirical example involving the application of this method to the Japanese economy.

A preliminary summary of the conclusions obtained from the survey just discussed is as follows:

(1) The test results of the LSW proposition concerning the Japanese economy

consistently suggest that the LSW proposition does not hold despite the following improvements in empirical methodology,

i) refinement of the output equation and the money forecasting equation in line with reality (Seo and Takahashi (1981), and also Hamada and Hayashi (1985));

ii) relaxation of the assumptions regarding the nature of errors (Hamada and Hayashi (1985)); and

iii) adoption of a more effective test method (Gochoco (1985)).

(2) Using Granger Causality, Parkin (1984) suggests that LSW proposition is supported if original data are used. However, Parkin's result cannot be said to be persuasive enough to disprove the findings of earlier studies. There are two reasons.

i) Empirical studies using Granger Causality, such as the one conducted by Parkin (1984), are designed to test the LSW proposition corresponding to the Classical model containing specific simple output functions. They are not necessarily tests that correspond to the usual Classical model.

ii) The fact that empirical results using Granger Causality are sensitive to the selection of the method of seasonal adjustment not necessarily mean that the Barro/Mishkin type tests noted earlier are also sensitive to the selection of the method for seasonal adjustment. In fact, Gochoco (1986) suggest that the LSW proposition is rejected in the case of either seasonally-adjusted or seasonally-unadjusted data.

(3) Taniuchi (1982) and Gochoco (1986) offer two alternative explanations for the failure of the LSW proposition. Taniuchi's findings suggest that the LSW proposition is rejected because the assumption of rationality of expectations is not satisfied due to the existence of an annual wage contract based on "Shunto" negotiations, while Gochoco's findings suggest that the LSW proposition is rejected because it fails to meet the assumption of neutrality.

Finally, as the agenda for future study, several remaining problems of empirical study will be pointed out. While considering these points may make it even more difficult to establish the LSW proposition, examination of these points is extremely useful in further deepening our knowledge of the operative features of the Japanese economy.

In Section II, a survey on the empirical tests of LSW proposition is undertaken by going through the works of Pigott (1978), Seo and Takahashi (1981), Hamada and Hayashi (1985), Taniuchi (1982), Parkin (1984), Mishkin (1983) and Gochoco (1985).

Then in Section III, the conclusion of this paper are summarized into four problems for the future; the problems of information set at the time of expectation formation, degree of freedom, observational equivalency, and function of price.

II. Empirical Test of the LSW Proposition in the Japanese Economy

Empirical test of the LSW proposition as it relates to the Japanese economy was initiated with Pigott (1978), which followed in the footsteps of Barro (1977). Since then, studies undertaken by Seo and Takahashi (1981), Taniuchi (1982), Parkin (1984), Hamada and Hayashi (1985), Gochoco (1985), etc. have been published. Below we will introduce the significance and problems of these studies one by one.

1. Barro-type Verification by Pigott (1978)

Pigott (1978) was the first researcher to attempt a Barro-type test of the Japanese economy. On the basis of the money supply (M_1) forecasting equation shown in Table 1, Pigott divided changes in the money supply between those anticipated and those unanticipated and measured their influence on real GNP as well as mining and industrial production (Table 2). As a result, Pigott found:

1) As evidenced by the fact that the coefficients of changes in anticipated money stock variables (for t=0, 1) are significant, anticipated changes in the money supply have an impact on the real economy, at least in the short run.[2]

2) Coefficients of unexpected changes in the money stock are only slightly significant, the influence of the unanticipated level of money stock on real economic activities, especially real GNP, is small.

This is clearly a rejection of the LSW proposition, and as such is in marked contrast to Barro's study of the U.S. economy, which supports the LSW proposition. However, if we want the results to be reliable, the output equation must be of proper reduced form, and the division between the anticipated money and the unanticipated money must be fully reliable. This was also a point at issue in verifying the influence of Barro (1977)'s unanticipated money stock changes on the unemployment rate. Small (1979) criticized Barro's findings and cited empirical results to back up his claim that (1) Barro's formulation for predicting the money stock is inappropriate, and (2) Barro's formulation of the natural unemployment rate is arbitrary. Although Barro (1979) countered this by insisting that his basic findings could be upheld even if Small's criticisms were taken into consideration, it is undeniable that the robustness of Barro's empirical findings has been called into question. Merrick (1983)'s criticism of Barro is also based on this point, and Seo and Takahashi (1981) discussed in the next

2. Since Pigott assumed *a priori* neutrality of money in the long run (that is, the sum of coefficients concerning anticipated money stock and unanticipated money supply in the output equation is zero), changes in the money stock in the long run have no influence on output. However, the legitimacy of this condition is placed in doubt for a Barro-type test.

section, also takes the same point into consideration.

2. Seo and Takahashi's Results

Seo and Takahashi (1981) can be regarded as a reexamination of Pigott's findings in terms of the money forecasting equation and the output equation. Seo and Takahashi, regarding as problematic the low precision of Pigott (1978)'s M_1 forecasting equation, considered Pigott (1978)'s findings unreliable because the specification

Table 1 Money Forecasting Equations[1]

Period: 1958: I – 1970: IV

$$\underset{}{DMIA(t)} = \underset{(4.43)}{.02} + \underset{(1.21)}{.044} \times DRSA(t-1) + \underset{(1.35)}{.052} \times DRSA(t-2) + \underset{(1.41)}{.209} \times DMIA(t-1) + \underset{(1.75)}{.226} \times DMIA(t-2).$$

Period: 1971: I – 1977: III

$$DMIA(t) = \underset{(4.43)}{.020} - \underset{(-3.00)}{.533} \times \{DJCPI(t-2) - DUSCPI(t-3)\} + \underset{(5.41)}{.576} \times DMIA(t-1).$$

Summary Statistics for the Entire Sample

R^2 (adjusted) = .36

Standard Error = .015

1958: I – 1970: IV[3] = .012

1971: I – 1977: III[3] = .017

Rho = .009

Durbin-Watson = 1.97

Sample Period = 1958: I – 1977: III

Number of Observations = 79

Sum of Coefficients of DRSA = .096
(2.88)

Notes: 1. The estimates were derived from a single equation applied to the entire sample, using multiplicative dummy variables.

2. DMIA = Difference between the current and previous quarter's logarithm of seasonally-adjusted M_1.
DRSA = Difference between the current and previous quarter's logarithm of seasonally-adjusted gold and foreign-exchange reserves.
DJCPI = Difference between the current and previous quarter's logarithm of the Japanese CPI.
DUSCPI = Difference between the current and previous quarter's logarithm of the U.S. CPI.

3. This is the square root of the sum of squared residuals divided by the number of observations; these are not strictly comparable with the standard error of the entire sample.

4. Figures in parentheses are "t" statistics.

Source: Pigott (1978)

Table 2 Summary of Regressions of the Activity Variables on the Money Growth Components

The estimate equation was:

$$\triangle X(t) = a_0 + a_1 \times T + \sum_{i=0}^{7} a_2(i)DMP(t-i) + \sum_{i=0}^{7} a_3(i)DMR(t-i) + \sum_{i=1}^{4} a_4(i)\triangle X(t-i),$$

where $\triangle X(t)$ is the activity variable, T is a time trend, DMP is predicted money growth and DMR is unanticipated money growth. The $\triangle X$, DMP, and DMR were also expressed as percentages (i.e. multiplied by 100).

Explanatory variables	Changes in: Log of Industrial Production		Log of Real GNP	
Constant	2.36	(3.06)	2.50	(4.07)
Time (Trend)	−0.02	(−2.33)	−0.02	(−2.72)
Anticipated Money Changes: (DMP_t)				
t = 0	0.52	(1.99)	0.47	(1.73)
−1	0.51	(1.52)	−0.23	(−0.50)
−2	0.16	(0.46)	0.11	(0.24)
−3	−1.20	(−3.52)	−0.39	(−0.87)
−4	0.89	(2.40)	0.56	(1.28)
−5	−0.08	(−0.21)	−0.29	(−0.65)
−6	−1.35	(−3.78)	0.19	(0.45)
−7	0.54	(1.87)	−0.42	(−1.72)
Unanticipated Money Changes: (DMR_t)				
t = 0	0.03	(0.24)	0.12	(1.02)
−1	−0.09	(−0.61)	−0.10	(−0.63)
−2	−0.16	(−1.10)	0.04	(0.20)
−3	−0.42	(−2.82)	−0.03	(−0.19)
−4	0.43	(2.67)	0.23	(1.31)
−5	0.06	(0.34)	−0.28	(−1.56)
−6	−0.22	(−1.27)	0.01	(0.00)
−7	0.38	(2.26)	0.02	(0.13)
Lagged Dependent Variable: ($\triangle X_t$)				
t = −1	0.53	(4.15)	0.43	(3.51)
−2	0.06	(0.46)	0.06	(0.41)
−3	0.07	(0.55)	0.02	(0.18)
−4	−0.10	(−0.90)	−0.20	(−1.69)
Rho (Cochrane-Orcutt correction)	−.03		−.58	
R^2 (adjusted)	.73		.30	
Standard Error of Regression	1.38		1.34	
Number of Observations	71		71	
Period	1960: I–1977: III		1960: I–1977: III	

Note: Figures in parentheses are "t" statistics.

of the M_1 forecasting equation is not necessarily appropriate.[3]

Seo and Takahashi, after a careful examination of the statement made by the Chairman of the Bank of Japan's Policy Board, indicated that throughout the 1960s and the 1970s, the Bank of Japan attatched importance to balance of payments, prices and effective demand, but that in the 1960s, the Bank tended to stress external balance (balance of payments), while in the 1970s it tended to stress internal balance (Table 3). Seo and Takahashi obtained an M_2 + CD forecasting equation consistent with the subjective policy objectives of the Bank of Japan for the two decades (Table 4). Furthermore, Seo and Takahashi generalized the output equation by taking into consideration the changes in the growth rate of natural output brought about by the First Oil Crisis as well as those in the oil price as a proxy for its disturbance effect. The empirical results obtained by combining the M_2 + CD forecasting equation and the output equation are shown in Tables 5 and 6.

The results are summarized by Seo and Takahashi as follows:

Table 3 Reasons for Discount Rate Changes Announced by the Policy Board

Date	Size of Change (%)	Balance of Payments	Exchange Rate	Wholesale Prices	Effective Demand
'60 8	−0.36			◎	○
'61 1	−0.37				
7	0.37	◎			○
9	0.36	◎			○
'62 10	−0.36	◎			
11	−0.37	◎			
'63 3	−0.36				
4	−0.37				
'64 3	0.73	◎			
'65 1	−0.36	◎			○
4	−0.37	◎			○
6	−0.36				◎
'67 9	0.36	◎			○
'68 1	0.37	◎			○
8	−0.37	◎			
'69 9	0.41			◎	○
'70 10	−0.25			◎	○
'71 1	−0.25	○			◎
5	−0.25	○			◎
7	−0.25	○			◎
12	−0.50	○			◎
'72 6	−0.50	◎			○
'73 4	0.75			○	◎
5	0.50			○	◎
'73 7	0.50			○	◎
8	1.00			○	◎
12	2.00			◎	
'75 4	−0.50				◎
6	−0.50				◎
8	−0.50				◎
10	−1.00				◎
'77 3	−0.50				◎
4	−1.00				◎
9	−0.75				◎
'78 3	−0.75	◎	○		○
'79 4	0.75	○	○	◎	
7	1.00			◎	
11	1.00		○	◎	
'80 2	1.00		○	◎	
3	1.75		○	◎	
8	−0.75				◎
11	−1.00				◎

Notes: ◎ primary reason ○ secondary reason
Source: Seo and Takahashi (1982)

3. However, there is no *a priori* standard in the rational expectations model with which one can determine how precise a certain variable should be. Thus the low precision of a forecasting equation itself cannot be regarded as being contrary to rational expectations.

(1) With regard to the Japanese economy from 1965 – 1980, the anticipated changes in the money supply exerted influence on real GNP as well as on mining and industrial production (though the influence was not always stable);
(2) Unanticipated changes in the money supply exerted a more definite influence on actual economic activities than did anticipated changes.

Seo and Takahashi concluded[4] that, while the significance of the anticipated money stock may be different from Pigott's findings, the LSW proposition is tentatively rejected by thus changing the money forecasting equation and the output

Table 4 Seo and Takahashi (1981)'s Money Forecast Equations

For the 1960s (1961: I to 1969: IV)

$$
\begin{aligned}
DM_t = {} & \underset{(2.662)}{2.223} + \underset{(2.107)}{0.378DM_{t-1}} + \underset{(1.453)}{0.317DM_{t-2}} + \underset{(0.230)}{0.054DM_{t-3}} - \underset{(-0.867)}{0.180DM_{t-4}} \\
& + \underset{(0.906)}{0.074RGNP_{t-1}} + \underset{(0.317)}{0.022RGNP_{t-2}} - \underset{(-2.597)}{0.165RGNP_{t-3}} - \underset{(-0.298)}{0.021RGNP_{t-4}} \\
& - \underset{(-2.672)}{0.374WPI_{t-1}} - \underset{(-0.232)}{0.142WPI_{t-2}} - \underset{(-0.233)}{0.056WPI_{t-3}} - \underset{(-1.146)}{0.259WPI_{t-4}} \\
& - \underset{(-0.663)}{0.011CA_{t-1}} + \underset{(2.202)}{0.033CA_{t-2}} - \underset{(-0.357)}{0.007CA_{t-3}} - \underset{(-0.347)}{0.000CA_{t-4}}
\end{aligned}
$$

$R^2 = 0.629$ S.E. = 0.467

For the 1970s (1970: I to 1980: IV)

$$
\begin{aligned}
DM_t = {} & \underset{(1.663)}{0.619} + \underset{(1.979)}{0.312DM_{t-1}} + \underset{(1.320)}{0.294DM_{t-2}} + \underset{(1.470)}{0.373DM_{t-3}} - \underset{(-0.098)}{0.024DM_{t-4}} \\
& - \underset{(-2.404)}{0.029DI_{t-1}} + \underset{(0.095)}{0.002DI_{t-2}} + \underset{(0.676)}{0.012DI_{t-3}} + \underset{(0.741)}{0.010DI_{t-4}} \\
& + \underset{(0.170)}{0.016CPI_{t-1}} - \underset{(-2.006)}{0.134CPI_{t-2}} - \underset{(-1.368)}{0.107CPI_{t-3}} - \underset{(-0.804)}{0.071CPI_{t-4}}
\end{aligned}
$$

$R^2 = 0.859$ S.E. = 0.490

Notes:

DM	M_2 + CD (seasonally-adjusted, log difference from previous term)
RGNP	Real income (same as above)
DI	Index for judging short-range business conditions nationwide
WPI	Wholesale price index (seasonally-adjusted, log difference from previous term)
CPI	Consumer price index (same as above)
CA	Current account balance (seasonally-adjusted)

Numbers in parentheses are t-values

Source: Seo and Takahashi (1981)

4. Seo and Takahashi, referring to observational equivalence and other problems associated with using a reduced form equation, regarded these findings as "tentative".

equation. However, in Seo and Takahashi, as the low Durbin-Watson values in Cases (1) and (2) of Table 5 and 6 indicate that, errors in the output equations have strong serial correlation and suggest the possibility of misspecification. In the next section, this point will be examined.

3. Exogeneity of Errors and Coefficient Bias — Hamada and Hayashi (1985) —

Hamada and Hayashi (1985) uses monthly data to reexamine the M_2 forecasting equation (using the ratio of foreign currency reserves as the explanatory variable instead of the current balance, and using the Chow test to statistically detect the structural changes). As a result, Hamada and Hayashi conclude that the M_2 forecasting equation has shifted in accordance with the adoption of the floating exchange system, and the change in this parameter suggests that the exchange rate has replaced foreign exchange reserves as an important policy objective (Tables 7, 8).[5]

Meanwhile, the output equation is formulated in much the same way as in Seo and Takahashi (1981). But the First Oil Shock is treated differently because the oil price index is not included while the oil shock dummy (January 1974 and after = 1, before = 0) is, and fourth order auto-regression

$$u_t = \rho_1 u_{t-1} + \rho_2 u_{t-2} + \rho_3 u_{t-3} + \rho_4 u_{t-4} + \text{white noise}$$

is assumed for the error term.

The auto-regression was assumed for the error term because the results of Pigott (1978) and those of Seo and Takahashi indicate a strong serial corelation. However, since $\rho_2 - \rho_4$ are all insignificant, this expansion is not thought to have been very important.

According to the above framework, as shown in Figure 1, the anticipated money stock has a significant influence on real output (the F value is significant at the 1-percent level). In the M_2 forecasting equation, the results of estimates shown in Table 7A were used for the period of fixed exchange rate system, and those shown in

5. The use of monthly data has the clear advantage of increasing the degree of freedom, but it is unclear whether it is actually reliable to use the month as a unit of duration for testing the LSW proposition. Although Hamada and Hayashi (1985) do not delve into this point, it may be somewhat unrealistic to expect people to make projections about money stock every month and adjust their production accordingly. Moreover, considering the fact that the Bank of Japan announces its money stock supply forecasts every quarter, it is difficult to regard monthly change in the money stock as a policy response. Consequently, it may also be difficult to interpret the M_2 forecasting equation as a function of the response by the monetary authorities.

Table 5 The Regressions of Real GNP with Money Supply

Estimate Equations of (1), (3) … $RGNP_t = b_0 + \sum_{i=0}^{9} b_{1i}(DMR)_{t-i} + b_2 TRND1 + b_3 TRND2 + b_4 OILP_t + v_t$.

Estimate Equations of (2), (4) … $RGNP_t = b_0 + \sum_{i=0}^{9} b_{1i}(DMR)_{t-i} + \sum_{i=0}^{9} b'_{1i}\widehat{DM}_{t-i} + b_2 TRND1 + b_3 TRND2 + b_4 OILP_t + v_t$.

Explanatory Variable	Equation (1)	t-value	(2)	t-value	(3)	t-value	(4)	t-value
CONST.	10.26	382.80	10.39	268.69	110.38	115.29	110.43	63.61
DMR_t	1.09	1.47	0.42	0.59	0.32	0.70	0.31	0.71
DMR_{t-1}	1.91	2.71	1.79	2.25	0.98	1.68	1.12	1.81
DMR_{t-2}	2.03	2.85	2.65	3.33	1.65	2.46	2.35	3.30
DMR_{t-3}	0.81	1.11	1.39	1.80	0.96	1.30	1.68	2.25
DMR_{t-4}	0.88	1.20	1.07	1.36	1.36	1.77	2.00	2.62
DMR_{t-5}	1.02	1.40	1.45	1.87	1.64	2.11	2.10	2.85
DMR_{t-6}	0.84	1.18	1.02	2.43	1.49	1.95	1.68	2.27
DMR_{t-7}	0.05	0.07	1.56	1.98	1.20	1.77	1.97	2.98
DMR_{t-8}	−0.71	−1.00	0.07	0.09	0.86	1.48	1.24	2.05
DMR_{t-9}	−1.36	−1.81	−0.18	−0.21	0.10	0.21	0.65	1.32
$\widehat{DM}_t$			−1.64	−1.71			0.57	0.90
$\widehat{DM}_{t-1}$			−1.86	−1.58			−1.15	−1.98
$\widehat{DM}_{t-2}$			1.59	1.28			0.73	1.13
$\widehat{DM}_{t-3}$			0.62	0.50			0.63	1.05
$\widehat{DM}_{t-4}$			−0.33	−0.30			0.97	1.69
$\widehat{DM}_{t-5}$			−0.34	−0.31			0.75	1.43
$\widehat{DM}_{t-6}$			−0.17	−0.17			−0.18	−0.35
$\widehat{DM}_{t-7}$			0.12	0.12			0.11	0.20
$\widehat{DM}_{t-8}$			−0.86	−0.92			−0.41	−0.86
$\widehat{DM}_{t-9}$			0.57	0.73			0.88	1.79
TRND1	2.60	63.39	2.65	53.58	2.40	14.25	1.72	4.19
TRND2	−1.26	−17.83	−1.40	−15.58	−1.05	−4.16	−0.28	−1.53
OILP	−6.47	−7.18	−7.92	−7.80	−4.44	−2.66	−2.30	−2.03
R^2	0.997		0.998		0.998		0.999	
S.E.	0.019		0.016		0.012		0.010	
D.W.	0.578		0.682		2.045		1.682	
ρ					0.859		0.927	

Notes:
- CONST Fixed number
- RGNP Real GNP, seasonally-adjusted, log difference from previous term
- DM M_2 + CD, seasonally-adjusted, log difference from previous term
- $\widehat{DM}$ Anticipated value for DM
- DMR DM − $\widehat{DM}$
- TRND1 Trends from 1965 – 1973
- TRND2 Trends from 1974 – 1980
- OILP Oil price index, log difference from previous term

Equation (3), (4) are both estimated in Cochrane-Orcutt procedure.

Source: Seo and Takahashi (1981)

Table 6 Money Supply and Industrial Production

Estimate Equations of (1), (3) ... $IIP_t = b_0 + \sum_{i=0}^{9} b_{1i}(DMR)_{t-i} + b_2TRND1 + b_3TRND2 + b_4OILP_t + v_t.$

Estimate Equations of (2), (4) ... $IIP_t = b_0 + \sum_{i=0}^{9} b_{1i}(DMR)_{t-i} + \sum_{i=0}^{9} b'_{1i}\widehat{DM}_{t-i} + b_2TRND1 + b_3TRND2 + b_4OILP_t + v_t.$

Explanatory Variable	Equation							
	(1)	t-val.	(2)	t-val.	(3)	t-val.	(4)	t-val.
CONST.	3.64	50.19	3.94	42.43	4.01	10.23	4.23	16.32
DMR_t	4.63	2.32	3.42	2.60	1.23	1.29	1.03	1.49
DMR_{t-1}	4.47	2.36	4.58	2.39	1.37	2.07	2.77	2.62
DMR_{t-2}	2.87	1.49	4.42	2.30	1.03	0.71	3.50	2.89
DMR_{t-3}	1.87	0.97	3.97	2.12	1.19	0.73	4.08	3.16
DMR_{t-4}	1.64	0.87	3.37	1.79	1.59	0.95	4.04	3.10
DMR_{t-5}	2.46	1.26	3.06	2.77	2.33	1.40	4.05	3.28
DMR_{t-6}	2.50	1.31	3.70	3.37	2.67	1.61	4.03	3.61
DMR_{t-7}	−0.85	−0.44	2.97	1.57	1.27	0.85	3.61	3.20
DMR_{t-8}	−2.89	−1.51	−0.15	−0.08	0.65	0.53	2.62	2.48
DMR_{t-9}	−2.31	−1.15	1.54	0.75	0.39	0.43	1.44	1.78
$\widehat{DM}_t$			−5.75	−2.49			−0.81	−0.79
$\widehat{DM}_{t-1}$			−2.00	−0.71			−0.41	−0.44
$\widehat{DM}_{t-2}$			3.28	1.11			1.36	1.30
$\widehat{DM}_{t-3}$			0.12	0.04			2.37	2.30
$\widehat{DM}_{t-4}$			−0.74	−0.28			2.08	2.15
$\widehat{DM}_{t-5}$			0.52	0.20			2.32	2.71
$\widehat{DM}_{t-6}$			0.59	0.24			0.28	0.33
$\widehat{DM}_{t-7}$			0.25	0.10			0.73	0.83
$\widehat{DM}_{t-8}$			−1.36	−0.60			0.70	0.88
$\widehat{DM}_{t-9}$			0.40	−0.21			0.83	1.04
TRND1	2.94	27.50	2.94	25.26	1.70	2.59	1.26	2.03
TRND2	−1.68	−9.11	−1.82	−8.43	−0.43	−0.63	0.21	0.37
OILP	13.82	−5.62	−16.79	−6.88	−6.31	−1.64	−1.53	−0.49
R^2	0.975		0.986		0.994		0.997	
S.E.	0.051		0.039		0.025		0.017	
D.W.	0.433		0.594		1.215		1.406	
ρ					0.941		0.939	

Note: IIP; industrial production index, seasonally-adjusted log. See Table 5 for definitions of other variables.

Equations (3), (4) are both estimated in Cochrane-Orcutt procedure.

Source: Seo and Takahashi (1982)

Table 8 were used for the period of the floating exchange rate system.

Although Hamada and Hayashi (1985) use somewhat different M_2 forecasting equations to conduct the same calculation, the results are nearly the same. These results, like those obtained by Pigott (1978) and by Seo and Takahashi (1981), seem to suggest that anticipated money stock has an influence on real output.

Furthermore, in Hamada and Hayashi (1985), the relation between output and fiscal expenditure is checked from the standpoint that it is wrong to assume the errors in the output equation to be exogenous.

Let us first show the relation between y_t and p_t from a conventional IS-LM curve instead of the monetary total demand index. That is,

$$y_t = f_t - \beta r_t + v_{1t}\ , \qquad \text{IS curve} \quad (1)$$

$$m_t = p_t + y_t + \delta r_t + v_{2t}\ , \qquad \text{LM curve} \quad (2)$$

where,

y_t: defined as the deviation from the full employment output corresponding to the natural unemployment rate,

m_t: the money supply, p_t the general price level, and v_{1t} and v_{2t} are the independent white noises. All the variables will be measured with logarithm unless otherwise stated,

f_t: the fiscal expenditure, and r_t the nominal interest rates (in anti-logarithm).[6]

If the total demand function is shown by eliminating r_t from (1) and (2),

$$m_t = p_t + Ay_t - X_t - \frac{\delta}{\beta} v_{1t} + v_{2t}\ , \qquad (3)$$

$$(\text{ where } A = \frac{\beta + \delta}{\beta},\ X_t = \frac{\delta}{\beta} f_t\ ).$$

From the demand balance condition combining (2) and the simple Lucas-type demand function, we obtain

$$E_{t-1}P_t = E_{t-1}m_t + E_{t-1}X_t\ , \qquad (4)$$

and

$$y_t = a(m_t - E_{t-1}m_t) + a(X_t - E_{t-1}X_t) + u_{1t}\ , \qquad (5)$$

(where $E_{t-1}\ Z_t$ denotes the expected value of Z_t given the information at t-1).

Here, if, in place of (5), output equation is calculated with

$$y_t = a(m_t - E_{t-1}m_1) + u_t\ ,$$

then,

$$u_t = a(X_t - E_{t-1}X_t) + u_{1t}\ ,$$

6. As a general formulation, it may be possible to take into consideration the influence on interest rates of the expected rate of inflation, but for the sake of simplicity, this effect will not be considered here.

Table 7 Hamada and Hayashi (1985)'s Money Supply Forecast Equations (1)

A. October 1965 – January 1973

R.H.S. variable	Point estimate	t-value	R.H.S. variable	Point variable	t-value
DM_{t-1}	−0.319	(−2.20)	DIP_{t-1}	−0.0245	(−0.45)
DM_{t-2}	0.00872	(0.06)	DIP_{t-2}	−0.0330	(−0.59)
DM_{t-3}	0.0855	(0.56)	DIP_{t-3}	−0.000806	(−0.02)
DM_{t-4}	0.109	(0.73)	DIP_{t-4}	−0.100	(−1.94)
DM_{t-5}	−0.0100	(−0.07)	DIP_{t-5}	−0.116	(−2.12)
DM_{t-6}	0.215	(1.47)	DIP_{t-6}	−0.174	(−3.24)
DM_{t-7}	0.0187	(0.13)	DIP_{t-7}	0.0364	(0.59)
DM_{t-8}	−0.114	(−0.88)	DIP_{t-8}	0.108	(1.74)
$DCPI_{t-1}$	0.159	(1.48)	$RRSV_{t-1}$	0.000490	(0.06)
$DCPI_{t-2}$	0.0830	(0.76)	$RRSV_{t-2}$	−0.000458	(−0.04)
$DCPI_{t-3}$	−0.0121	(−0.12)	$RRSV_{t-3}$	0.0108	(0.92)
$DCPI_{t-4}$	0.0575	(0.53)	$RRSV_{t-4}$	−0.00348	(−0.29)
$DCPI_{t-5}$	0.137	(1.20)	$RRSV_{t-5}$	−0.0207	(−1.73)
$DCPI_{t-6}$	0.0132	(0.12)	$RRSV_{t-6}$	0.00794	(0.74)
$DCPI_{t-7}$	−0.0555	(−0.50)	$RRSV_{t-7}$	0.00412	(0.04)
$DCPI_{t-8}$	−0.0257	(−0.24)	$RRSV_{t-8}$	0.00885	(1.20)
			Intercept	0.0128	(2.13)

R^2 = 0.565. Standard error of regression = 0.00409.
Mean of dependent variable (DM_t) = 0.0144.
Standard deviation of DM_t = 0.00493.

B. February 1973 – December 1982

R.H.S. variable	Point estimate	t-value	R.H.S. variable	Point estimate	t-value
DM_{t-1}	−0.153	(−1.51)	DIP_{t-1}	−0.0605	(−1.29)
DM_{t-2}	−0.203	(−1.99)	DIP_{t-2}	0.0328	(0.69)
DM_{t-3}	0.134	(1.37)	DIP_{t-3}	0.00339	(0.07)
DM_{t-4}	0.175	(1.83)	DIP_{t-4}	0.0270	(0.55)
DM_{t-5}	0.103	(1.00)	DIP_{t-5}	0.0962	(1.96)
DM_{t-6}	0.261	(2.53)	DIP_{t-6}	−0.109	(−2.28)
DM_{t-7}	0.0881	(0.86)	DIP_{t-7}	−0.0583	(−1.33)
DM_{t-8}	0.109	(1.08)	DIP_{t-8}	−0.0453	(−1.04)
$DCPI_{t-1}$	0.0714	(0.78)	$RRSV_{t-1}$	0.00805	(1.10)
$DCPI_{t-2}$	0.0609	(0.66)	$RRSV_{t-2}$	−0.00457	(−0.40)
$DCPI_{t-3}$	0.0499	(0.52)	$RRSV_{t-3}$	0.00585	(0.51)
$DCPI_{t-4}$	−0.0595	(−0.63)	$RRSV_{t-4}$	−0.00931	(−0.83)
$DCPI_{t-5}$	0.137	(1.49)	$RRSV_{t-5}$	0.00163	(0.14)
$DCPI_{t-6}$	−0.130	(−1.36)	$RRSV_{t-6}$	0.0000579	(0.01)
$DCPI_{t-7}$	0.132	(1.38)	$RRSV_{t-7}$	0.00350	(0.31)
$DCPI_{t-8}$	−0.256	(−2.73)	$RRSV_{t-8}$	−0.00397	(−0.53)
			Intercept	0.00268	(1.05)

R^2 = 0.496. Standard error of regression = 0.00515.
Mean of dependent variable (DM_t) = 0.00916.
Standard deviation of DM_t = 0.00619.

Notes:
- DM: M_2's month-to month growth rate (seasonally-adjusted after Oct. 11)
- DCPI: CPI's month-to-month growth rate (same as above)
- DIP: Industrial production (IP)'s month-to-month rate of increase (seasonally-adjusted after Oct. 11)
- RRSV: Foreign currency reserves ($1 million) deflated with VPI x IP (seasonally-adjusted after Oct. 11)

Source: Hamada and Hayashi (1985)

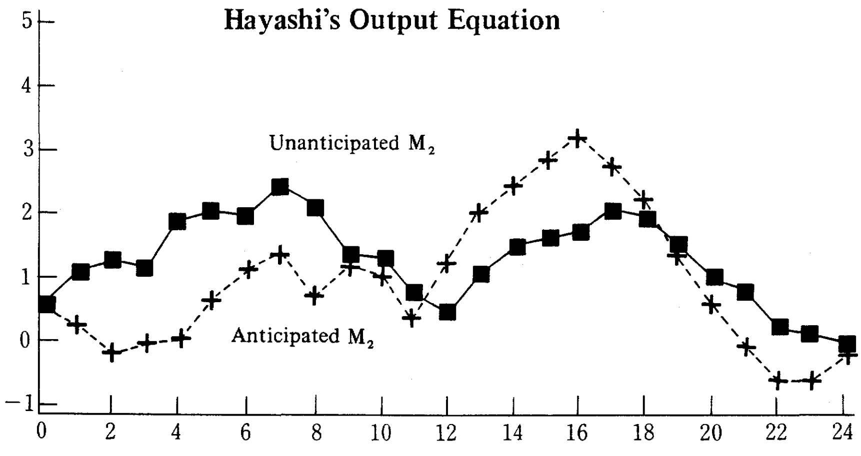
Table 8 Hamada and Hayashi (1985)'s Money Supply Forecast Equations (2)

– Case where the exchange rate is added to the explanatory variables under the floating exchange rate system –

R.H.S. variable	Point estimate	t-value	R.H.S. variable	Point estimate	t-value
DM_{t-1}	−0.122	(−1.15)	DIP_{t-1}	−0.101	(−2.26)
DM_{t-2}	−0.148	(−1.39)	DIP_{t-2}	0.0228	(0.51)
DM_{t-3}	0.135	(1.38)	DIP_{t-3}	0.0117	(0.25)
DM_{t-4}	0.136	(1.43)	DIP_{t-4}	0.0473	(1.02)
DM_{t-5}	0.0849	(0.85)	DIP_{t-5}	0.0902	(1.98)
DM_{t-6}	0.239	(2.47)	DIP_{t-6}	−0.111	(−2.41)
DM_{t-7}	0.0687	(0.68)	DIP_{t-7}	−0.0524	(−1.14)
DM_{t-8}	0.0667	(0.69)	DIP_{t-8}	−0.0187	(−0.41)
$DCPI_{t-1}$	0.0144	(0.17)	$EXYS_{t-1}$	0.0000827	(0.99)
$DCPI_{t-2}$	0.0254	(0.29)	$EXYS_{t-2}$	−0.000175	(−1.30)
$DCPI_{t-3}$	0.00984	(0.11)	$EXYS_{t-3}$	−0.0000538	(−0.39)
$DCPI_{t-4}$	−0.0846	(−0.91)	$EXYS_{t-4}$	0.000216	(1.56)
$DCPI_{t-5}$	0.0543	(0.59)	$EXYS_{t-5}$	−0.0000684	(−0.49)
$DCPI_{t-6}$	−0.141	(−1.57)	$EXYS_{t-6}$	0.0000195	(0.22)
$DCPI_{t-7}$	0.127	(1.40)			
$DCPI_{t-8}$	−0.250	(−2.76)			
$DCPI_{t-9}$	0.0739	(0.77)			
$DCPI_{t-10}$	0.0191	(0.20)			

Notes: R^2 = 0.518. Standard error of regression = 0.00503. Sample period: February 1973 – December 1982. See Table 7 for definitions of variables.
Numbers in parentheses are t-values.
Source: Hamada and Hayashi (1985)

Figure 1 Money Supply Coefficient Pattern in Hamada and Hayashi's Output Equation



Source: Hamada and Hayashi (1985)

that is, the error term will be the function $X_t - E_{t-1} X_t$.

If $X_t - E_{t-1} X_t$ is correlated with $m_t - E_{t-1} m_t$, *a* will be biased since a correlation would arise between the error term and the explanatory variables. Similarly, the main factors determining output are not included among the explanatory variables in the output equation but are included among the error term, and if these factors are correlated with fluctuations in the money stock, it is possible that the anticipated money stock will appear to be significant.

Although Hamada and Hayashi (1985) treat fiscal expenditure as a candidate for such a missing variable, in their actual tests, instead of using the output equation that includes fiscal expenditure, they adopted a Granger test. Since the results of their investigation (Table 9) reveal that M_2 "causes" mining and industrial production even when fiscal expenditure is included, Hamada and Hayashi conclude that the LSW proposition is not established.

The range of models tested with procedure adopted by Barro is different from the range of models tested with Granger Causality. This point will be examined when we introduce the research findings obtained by Parkin (1984).

Table 9 Granger Test of Industrial Production in Hamada and Hayashi (1985)

	Amount of F-statistics		
Lag length	DM (amount of difference in M_2) coefficients are zero	DG (amount of difference in fiscal expenditure) coefficients are zero	Sample period
12 months	3.41[a]	1.40	Feb. 1966 to Dec. 1982
24 months	2.46[a]	2.25[b]	Feb. 1967 to Dec. 1982

Notes: a. Significant at the 5% level The data are all seasonally-adjusted logs.
b. Significant at the 1% level
Source: Hamada and Hayashi (1985)

4. Fischer's Barro Criticism and Prior Expectations Model —Taniuchi's Empirical Analysis —

The survey of empirical results thus far indicates that, with regard to the Japanese economy, changes in the anticipated money stock influence real output. Fischer (1980) stresses the importance of long-term wage contracts, aims to explain these results.

According to Fischer, since the wage level is unchanged from the time new wage contracts take effect until the next contracts are concluded, the situation is not that unanticipated changes in the money stock in each quarter exert influence on real output, but that unanticipated changes in the money stock at the time wages are revised exert influence on output. In this case, the simple Lucas-type supply function

$$y_t = \alpha (P_t - E_{t-1}P_t) + u_{1t}, \quad \alpha > 0 , \tag{6}$$

is an inappropriate specification. The correct specification is

$$y_t = \alpha (P_t - E^*P_t) + u_{1t}, \quad \alpha > 0 , \tag{6$'$}$$

where, E^*P_t is the expected value of prices at time t when the wage contracts are concluded.

Let us asskume that wage contracts are revised once a year. If wages are assumed to be revised in the second quarter,

$$\begin{aligned} E^*P_t &= E_{t-1}P_t \text{ (if } t \text{ is in the second quarter of that year),} \\ &= E_{t-2}P_t \text{ (if } t \text{ is in the third quarter of that year),} \\ &= E_{t-3}P_t \text{ (if } t \text{ is in the fourth quarter of that year),} \\ &= E_{t-4}P_t \text{ (if } t \text{ is the first quarter of the following year).} \end{aligned}$$

Taniuchi (1982) carried out an empirical study from the standpoint of the world à la Fischer, in which the author turns his attention to the annual "Shunto" wage negotiations in Japan and assumes that all wages in the Japanese economy are revised only once every year, in the second quarter. The main alternative hypothesis in this case is that wage levels are made fully flexible by bonus payments, etc., and Equation (6) of the Barro-Lucas type is of course the correct formulation.

Therefore, Taniuchi (1982) estimates Barro's model system containing (6) and Fischer's model system also containing (6)′ and compares explanatory power and stability. Furthermore, Taniuchi compares the estimation results with reduced form estimation results of the formulation in which the level of the money stock itself directly exerts influence on real output (Taniuchi calls this a Keynesian model). That is, Taniuchi (1982)'s interest can be considered by dividing it into two levels:

1) Comparison of a model which uses the level of money stock itself (Keynesian model) and a model which uses unanticipated money stock (Barro model and Fischer model).

2) After assuming a neutrality proposition, comparison of the formulation of un-

anticipated money stock using a Barro-Lucas-type approach (Barro model) and Fischer-type approach (so-called prior expectations model).

In actually carrying out the empirical tests, Taniuchi first estimated the money supply forecast equation (that is, money supply rules) (Table 10), and used the results thus obtained to estimate and compare the output equations corresponding to the three models noted above (Table 11).[7]

With regard to the results shown in Table 11, turning his attention to the F values concerning the significance of the money stock coefficient in each model and

7. However, the prior expectations model requires the expectation values of the explanatory variables in the money forecast equation at the time wages contracts are revised. Therefore, Taniuchi estimates the ARIMA model shown in Table 12 for each explanatory variable and uses the resultant expectation values. As Taniuchi himself points out, there is a problem that this step may not necessarily be consistent with the assumption of rationality of expectations.

Univariate ARIMA Models for R, DP, and DIIP

R_t (Reserve variable): AR (2) model 1960: I – 1972: IV

$$R_t = \underset{(1.72)}{47094.6} + \underset{(7.92)}{1.094}R_{t-1} - \underset{(-3.41)}{.470}R_{t-2}$$

$$\bar{R}^2 = .596 \qquad SEE = .185\times10^6$$

DP_t (Inflation rate): MA (3) model 1960: I – 1980: II

$$DP_t = \underset{(5.98)}{.0175} + u_t + \underset{(8.11)}{.615}u_{t-1} + \underset{(3.43)}{.356}u_{t-2} + \underset{(9.47)}{.700}u_{t-3}$$

$$\bar{R}^2 = .454 \qquad SEE = .0100$$

$DIIP_t$ (Industrial production index growth): AR (1) model 1960: I – 1980: II

$$DIIP_t = \underset{(2.45)}{.0065} + \underset{(8.78)}{.704}DIIP_{t-1}$$

$$\bar{R}^2 = .480 \qquad SEE = .0177$$

Notes: 1. The foreign currency reserve is estimated for the fixed exchange rate period; the inflation rate and the DIIP for mining and industrial production are estimated for the entire period.

2. The identification of the ARIMA model, the estimation of the coefficients, and the forecast were carried out according to the IDENT, ESTIMATE, and FORECAST programs developed by Nelson. The above coefficients were estimated according to the method of maximum likelihood.

Source: Taniuchi (1982)

Table 10 Taniuchi's Money Supply Forecast Equation

[A] Fixed Rate Period 1960: IV – 1972: IV

DM_{t-1}	.623	(5.22)
R_t	$.11 \times 10^{-7}$	(2.11)
R_{t-1}	$-.11 \times 10^{-7}$	(−1.46)
R_{t-2}	$.12 \times 10^{-7}$	(1.66)
$DIIP_{t-1}$	−.013	(−.21)
$DIIP_{t-2}$	−.116	(−1.85)
$BOND_t$	$-.31 \times 10^{-4}$	(−2.00)
$BOND_{t-1}$	$-.55 \times 10^{-5}$	(−.40)
$BOND_{t-2}$	$.36 \times 10^{-4}$	(2.48)
Constant	.020	(3.67)
$\bar{R}^2$	.590	
SEE	.00544	
DW	2.38	

[B] Flexible Rate Period 1973: I – 1980: II

DP_{t-1}	−.136	(−2.56)
DP_{t-2}	−.196	(−2.91)
$DIIP_{t-1}$	.050	(1.18)
$DIIP_{t-2}$	.040	(.99)
$DIIP_{t-3}$	−.013	(−.34)
$DIIP_{t-4}$	−.789	(−2.36)
T	$-.99 \times 10^{-3}$	(−9.44)
Constant	.105	(12.40)
$\bar{R}^2$	.822	
SEE	.00355	
DW	1.93	

Notes: t-values are in parentheses.
DM : Money supply (M_2)'s rate of change.
R : Fluctuations in foreign currency reserves (yen-indicated). Calculated by multiplying the yen rate by the yen-indicated foreign currency reserves.
DP : Inflation rate (rate of change in consumer price index).
DIIP : Rate of change in industrial production index (IIP)
BOND : Amount of government bonds issues.
T : Time trend.
(Seasonally-adjusted data are used in the estimates).
Source: Taniuchi (1982)

Table 11 Output Equation

[Prior Expectations Model]

	Total Period 1962: II – 1980: II		Fixed Rate Period 1962: II – 1972: IV		Flexible Rate Period 1973: I – 1980: II	
Y_{t-1}	1.171	(11.31)	1.166	(7.85)	1.087	(6.05)
Y_{t-2}	−.004	(−.29)	.101	(.46)	−.180	(−.66)
Y_{t-3}	−.274	(−2.77)	−.408	(−2.82)	−.061	(−.34)
$PDMR_t$	.409	(1.75)	.226	(.64)	.642	(1.40)
$PDMR_{t-1}$	.256	(1.03)	.378	(1.10)	.409	(.90)
$PDMR_{t-2}$	.408	(1.67)	.570	(1.75)	.432	(.94)
$PDMR_{t-3}$	−.807	(−3.19)	−.715	(−2.06)	−.760	(−1.53)
$PDMR_{t-4}$	.937	(3.90)	.691	(2.02)	1.301	(3.35)
Constant	.0008	(.64)	.0015	(.79)	.0004	(.21)
$\bar{R}^2$	.921		.911		.927	
SEE	.0106		.0119		.00942	
DW	2.13		2.18		2.30	
Joint Significance of PDMR's	F (5, 64) = 5.80**		F (5, 34) = 2.70*		F (5, 21) = 3.41**	

The sum of the coefficients on PDMR's;
Σ PDMR = 1.203 (in the total period)
= 1.150 (in the fixed rate period)
= 2.024 (in the flexible rate period)

The invariance test
F (9, 55) = .50

[Keynesian Model]

	Total Period		Fixed Rate Period		Flexible Rate Period	
Y_{t-1}	.969	(8.42)	.885	(5.30)	.735	(3.71)
Y_{t-2}	.182	(1.27)	.361	(2.06)	−.125	(−.54)
Y_{t-3}	−.281	(−2.81)	−.413	(−3.03)	.264	(1.51)
M_t	−.217	(−.99)	−.138	(−.46)	−.033	(−.10)
M_{t-1}	.438	(1.06)	.223	(.39)	.583	(1.05)
M_{t-2}	.643	(1.54)	.993	(1.68)	.086	(.18)
M_{t-3}	−1.514	(−3.54)	−1.503	(−2.39)	−1.277	(−2.49)
M_{t-4}	.568	(2.20)	.300	(.72)	.382	(1.11)
Constant	.0001	(.10)	−.002	(−.99)	.008	(2.71)
$\bar{R}^2$	.920		.924		.945	
SEE	.0106		.0110		.0082	
DW	1.91		2.16		2.06	
Joint Significance of M's	F (5, 64) = 5.64**		F (5, 34) = 4.30**		F (5, 21) = 5.79**	

The sum of the coefficients on M's;

ΣM = −.082 (in the total period)
= −.126 (in the fixed rate period)
= −.258 (in the flexible rate period)

The invariance test
F (9, 55) = 1.93; F (9, 60) (5%) = 2.04

[Barro's Model]

	Total Period		Fixed Rate Period		Flexible Rate Period	
Y_{t-1}	1.199	(10.36)	1.190	(7.82)	1.195	(5.53)
Y_{t-2}	−.084	(−.46)	.034	(.14)	−.244	(−.73)
Y_{t-3}	−.244	(−2.18)	−.324	(−2.09)	−.118	(−.60)
DMR_t	.292	(.84)	.186	(.44)	.350	(.44)
DMR_{t-1}	.287	(.85)	.190	(.44)	.926	(1.28)
DMR_{t-2}	.920	(2.73)	1.158	(2.70)	.571	(.78)
DMR_{t-3}	−.467	(−1.38)	−.141	(−.33)	−.689	(−.86)
DMR_{t-4}	.478	(1.33)	.528	(1.21)	.481	(.57)
Constant	−.0001	(−.12)	.0011	(.55)	−.0013	(−.58)
$\bar{R}^2$	.906		.907		.887	
SEE	.0115		.0121		.0118	
DW	2.14		2.25		2.12	
Joint Significance of DMR's	F (5, 64) = 2.89*		F (5, 34) = 2.25		F (5, 21) = .68	

The sum of the coefficients on DMR's;

ΣDMR = 1.509 (in the total period)
= 1.921 (in the fixed rate period)
= 1.638 (in the flexible rate period)

The invariance test
F (9,55) = .47

Notes: t-values are in parentheses.
* significant at the 5% level
**significant at the 1% level
Source: Taniuchi (1982)

to the Chow test concerning the significance of structural changes (invariability test), Taniuchi concludes that the prior expectations model is more or less supported. The reasons he gives are:

(1) In the prior expectations model, the unanticipated changes in the money stock (when wages are revised) are highly significant, while the output equation is stable (that is, the F value in the Chow test is small);

(2) In the Keynesian model, although the money stock is significant, the output equation is unstable (that is, the F value in the Chow test is large); and

(3) In the Barro model, the unanticipated change in the money stock is substantially less significant than in the case of the prior expectations model.

However, Taniuchi reports that the explanatory power of the prior expectations model is reduced considerably by adding fiscal expenditures and exports to the output equation. This suggests that the problem concerning the assumed exogeneity of the error term in the output equation indicated by Hamada and Hayashi (1985) may be crucial.

The empirical results reported so far consistently reject the LSW proposition. However, these empirical analyses are all based on seasonally-adjusted data, and it is problematical whether the same conclusions would have been reached if seasonally-unadjusted data had been used. Parkin's study, which we will take up in the next section, stresses the importance of this distinction.

5. Distinction between Prior Expectations Model Using Granger Causality and LSW-type Classical Model
— Problems with Verification Using Parkin (1984) and Granger Causality —

Parkin (1984), who calls Fischer-type of prior expectations model a Keynesian model, also compares the Classical model with Keynesian (Fischer-type) model. The method he used is the direct Granger test, one of the outstanding feature of his test procedure is that it carefully examines the influence of adjustment of seasonality and trend removal on the empirical results.

The following two quarterly models are the theoretical models that Parkin (1984) compared.[8]

The Keynesian model used here consists of the three Equations (7), (8), and (9):

$$y_t = \delta(P_t - \frac{1}{4}\sum_{i=1}^{4} E^*P_{t-i}) + \lambda y_{t-1} + \varepsilon_t. \quad (7)$$

8. For the sake of comparison, some of the symbols used below will be from Taniuchi (1982) and therefore different from the original paper. Moreover, the "Keynesian" model used here is Taniuchi (1982)'s prior expectations model, but, following Parkin (1984), here it will be called simply a "Keynesian model".

Where, ε is normally distributed white noise, that is $N(0, \sigma_{\varepsilon}^2)$. The aggregate supply y_t is the cyclical component of output, which is assumed to be capable of being decomposed into y_t + seasonal factor + trend.

$$y_t = m_t + V_t + P_t \ldots \text{ aggregate demand function.} \tag{8}$$

Where, V_t is the velocity of money, and the money supply (m_t) and the velocity of money are assumed to follow the exogenous stochastic process obtained from the bivariate autoregressive model expressed by the following equation:

$$\begin{bmatrix} m_t \\ V_t \end{bmatrix} = \begin{bmatrix} A'(L))B'(L) \\ C'(L)\ D'(L) \end{bmatrix} \begin{bmatrix} m_{t-1} \\ V_{t-1} \end{bmatrix} + t - 1 \begin{bmatrix} \eta_t \\ \xi_t \end{bmatrix} \tag{9}$$

$\eta \sim N(0, \sigma_{\eta}^2)$, $\xi \sim N(0, \sigma_{\xi}^2)$,[9]

where, $A'(L)$, etc. are the functions of a lag operator.

If rational expectations is assumed, the reduced form model obtained from (7) – (9) becomes

$$y_t = \frac{\delta}{1+\delta}\{A(L)\, m_{t-1} + B(L)\, V_{t-1}\} + \frac{\delta\,\phi}{1+\delta} y_{t-j} \tag{10}$$

$$+ \frac{\lambda}{1+\delta} y_{j-1} + \xi_t .$$

Where, y_{t-j} is the output at the end of the previous wage contract term (j = 1, 2, 3, or 4) and

$$\xi_t = \frac{1}{1+\delta}\{\varepsilon_t + \delta(\eta_t + \xi_t)\} \sim N(0, \sigma_{\xi}^2).$$

In contrast to this, the Classical model is expressed as a system consisting of (7)′, (8), and (9). Aggregate supply function is

$$y_t = a(P_t - E_{t-1}P_t) + \lambda y_{t-1} + \varepsilon_t , \tag{7$'$}$$

which is one variant of Lucas-type aggregate supply function. The reduced form model obtained from this system is

$$y_t = \lambda y_{t-1} + u_t , \tag{10$'$}$$

where,

$$u_t = \varepsilon_t + \frac{a}{1+a}(n_t + \xi_t) \sim N(0, \sigma_u^2).$$

Parkin emphasizes the following two points as a result of comparing the reduced form Keynesian model (10) and the reduced form Classical model (10)′:

(1) If the Classical model is correct, output should follow ARI, and if the Keyne-

9. Since the aggregate demand is defined as a cyclical factor after trend and seasonality have been removed, the velocity of money and the money stock, will also assume the above stochastic process with regard to the variables after seasonal and trend factors have been removed.

sian model is correct (because of the existence of the item y_{t-1}), the order of autoregression should differ according to season.
(2) If the Keynesian model is correct, the velocity of money and the money stock should cause output in the sense of Granger, while if the Classical model is correct, neither the velocity of money nor the money stock will "cause" output.

The first method Parkin (1984) adopted to confirm these points is as follows. First, constructing a general model that contains various models (Pigott (1978), Seo and Takahashi (1981), Hamada and Hayashi (1985), etc.) providing 16 coefficient conditions to the model that correspond to the various special cases, and carrying out a Granger test that takes into consideration the influence of trend, seasonality, and other factors on the empirical results (See Table 12).[10]

The general model used is expressed in Equation (11) below.

$$Y_t = a_0 + a_{1t} + \sum_{i=2}^{4} a_i S_{it} + a_5 d_{1t} + a_6 d_{1t} t + a_7 t^2 + a_8 d_{2t} S_{4t} + \sum_{i=1}^{5} a_{8+i} Y_{t-i} + \sum_{i=1}^{5} a_{13+i} M_{t-i} + \sum_{i=1}^{5} a_{18+i} V_{t-1} + \varepsilon_{t-1} + \varepsilon_t. \quad (11)$$

Table 12 Sixteen Restricted Models of Deterministic Trends and Seasonal Variations

Model	Zero restrictions on coefficients					Previous study
	(a_2-a_4)	a_5	a_6	a_7	a_8	
1						
2				O		
3		O	O			
4		O	O	O		
5					O	
6				O	O	
7		O	O		O	
8		O	O	O	O	Grossman and Haraf (1983)
9	O					
10	O			O		
11	O	O	O			
12	O	O	O	O		
13	O				O	Seo and Takahashi (1981) (SA), Taniuchi (1982) (SA), and Hamada and Hayashi (1985) (SA)
14	O			O	O	
15	O	O	O		O	Piggot (1978) (SA), and Oritani (1981)
16	O	O	O	O	O	

Notes: a_2-a_4 = Primary seasonal dummy
a_5 =Changes in the level of GDP trend in 1974: I
a_6 =Changes in trend since 1974: I
a_7 =Secondary trend
a_8 =Changes in fourth quarter seasonal after 1970: I
Source: Parkin (1984)

10. Since using seasonally-adjusted data is also possible for models No. 13-16, 20 models are actually compared.

Where,

t is an integral number (t = 1, ..., 64),

S_{it} = 1 (in the i th quarter),

= 0 (in other quarters),

d_{1t} = 0, 1967:I – 1973:IV,

= 1, 1974:I – 1982:I,

d_{2t} = 0, 1967:I – 1969:IV,

= 1, 1970:I – 1982:I.

The results (Table 13) indicate that, regardless of the specification of the trends, the Classical model is at a disadvantage when seasonally-adjusted data are used, while the same results indicate that conclusions will differ depending on the specification of the trends when seasonally-unadjusted data are used.

Next, Parkin (1984) estimates various real income time series models that explicitly contain trend and seasonal factors, regarded their residuals as the cyclical factors (y_t) of real income, and estimates the regressive equation that explains Y_t in terms of the money stock (in which the seasonal factors used in estimating y_t and the money stock m^r are identical). The specification is as follows:

Table 13 Granger Causality Between Money, Velocity and Real GDP

Model	Degree of Freedom	Money Causes Real GDP	Velocity Causes Real GDP
1	5,32	0.85	1.78
2	5,33	1.21	1.85
3	5,34	2.00	2.80*
4	5,35	1.64	2.58*
5	5,33	1.30	0.70
6	5,34	1.46	0.50
7	5,35	2.56*	1.04
8	5,36	1.80	0.60
9	5,35	1.33	1.40
10	5,36	2.16	1.42
11	5,37	2.40	1.82
12	5,38	2.06	1.65
13	5,36	1.48	1.08
14	5,37	2.10	0.98
15	5,38	2.57*	1.51
16	5,39	2.08	1.21
13SA	5,36	2.44	1.54
14SA	5,37	3.13*	1.06
15SA	5,38	3.49*	1.62
16SA	5,39	2.93*	1.12

Notes: $F_{.05}$ (5,30) = 2.53

$F_{.05}$ (5,40) = 2.45

* indicates rejection of the null hypothesis at the .05 level

Source: Parkin (1984)

$$y_t = \rho(L)y_{t-1} + \theta(L)\varepsilon_t + \sum_{i=1}^{5} k_i m^r_{t-1}. \tag{12}$$

When seasonally-unadjusted data are used (with the exception of models 5 – 7, which impose a condition that output follows a certain fixed seasonal pattern), the results of the F test for k_i indicate that since the money stock does not cause output, the LSW proposition is supported.

With regard to these results, Parkin (1984) insists that the Classical model should be regarded as being supported statistically more convincingly than is the Keynesian model. Parkin bases his argument on the fact that, since what makes the money stock cause real income in the Granger sense when seasonally-adjusted data are used is the "apparent causal relationship" that X-11 type moving average seasonal adjustment procedure bring about, empirical results obtained by using seasonally-unadjusted data are more reliable. The point at issue here may be considered in the following way: For the sake of simplicity, suppose there was no structural changes insofar as trend and seasonal factors are concerned, and real income can be thought of as being determined by the pure Classical mechanism plus seasonal factors. In other words,

$$y_t = \lambda y_{t-1} + u_t + S_t.$$

Where, S_t is the seasonal factor at t. Suppose there exists a function S(L) that will precisely neutralize the seasonality of y_t (when $S(L)\ S_t = 0$ for any t) the seasonally-adjusted real income $y^{SA}{}_t$ would yeild

$$y^{SA}{}_t = S\ (L)y_t = \lambda\ S(L)y_{t-1} + S(L)u_t\ ,$$

and the error u_t, the white noise, would be converted to the moving average. Therefore, if the innovation of the money stock were to be included in this u_t, the money stock's past innovation would appear to cause the current seasonally-adjusted real income.

Although Parkin suggests that examination of differences in the concept of output (mining and industrial production vis-à-vis real GNP), as well as the method of treating trend and changes in seasonality, may influence the results of the causal relationship, he seems to believe that the conclusion that the Classical school model is supported will not be changed.

However, there are three major reservations to this conclusion. First, since Parkin's insistence on the superiority of seasonally-unadjusted data involves Granger's test, his conclusion casts doubt on part of Hamada and Hayashi (1985)'s finding which uses direct Granger test. But his criticism of the findings of another part of Hamada and Hayashi (1985), Pigott (1978), Seo and Takahashi (1981), and Taniuchi (1982) is on shaky ground, for they are not based on Granger test.

Second, although test of the causal relationship between real GNP and money stock is often conducted in cases where the aim is not necessarily to verify the LSW proposition, a glance at these results seems to reveal that test based on seasonally unadjusted data is not necessarily supportive of the proposition that money stock does not cause real output. For example, although Komura (1982, 1984) and Ram (1984) employ seasonally unadjusted data, the results (Table 14) vary depending on the selection of the money stock (M_1 or M_2), the sample period and the testing method used (whether Granger test or Sims test using Mehra's filter).

Third, empirical tests using Granger Causality and those using the reduced form model developed by Barro are not identical. To be able to test the LSW proposition using Granger Causality without adopting a special statistical assumption, it is necessary to adopt an assumption corresponding to the simple Lucas-type aggregate supply function. Ever since Sargent advanced the test of the neutrality proposition using Granger Causality, this point has been argued by various researchers, including Nelson (1979), McCallum (1979), and Abel and Mishkin (1983).

Now, if the simple Lucas supply function is assumed to be correct, the true reduced form output equation may be expressed as

$$Y_t = \sum_{I=1}^{n} \lambda_i Y_{t-I} + \beta(m_t - E_{t-I} m_t) + u_t \, .$$

Here, Y_t can be interpreted as expressing actual output, while the weighted sum of the past values of Y_t can be interpreted as corresponding to natural output. Moreover, u_t is the white noise.

If we add the past money stock variable to this equation and drop unanticipated money stock $m_t - E_{t-1} m_t$ from the equation and estimate

$$Y_t = \sum_{i=1}^{n} \lambda_i Y_{t-i} + \sum_{i=1}^{n'} \alpha_i m_{t-i} + u_1. \qquad (13)$$

Table 14 Test of Granger Causality Between Money Stock and Real GNP by Komura (1983, 1984) and Ram (1984)

	Granger test	Sims test	Granger test	Sims test
(i) 1955: I - 1964: IV				
	M2 → *RGNP*	*M2* → ⇐ *RGNP*	*M1* → ⇠ *RGNP*	*M1* → ⇠ *RGNP*
(ii) 1955: I - 1971: II				
	M2 ⇒ ⇐ *RGNP*	*M2* ⇐ *RGNP*	*M1* → ⇐ *RGNP*	*M1* ⇢ *RGNP*
(iii) 1971: III - 1980: IV				
	M2 → ← *RGNP*	*M2* *RGNP*	*M1* *RGNP*	*M1* *RGNP*

⇒ F value is significant at 5% level at least for two types of lag specification
→ F value is significant at 5% level at least for one type of lag specification
⇢ F value is significant at 10% level at least for one type of lag specification

Note: RGNP = Real GNP
Source: Komura (1984)

Then, $m_{t-i}1$ (i = 1, ..., n') does not contain any information about $m_t - E_{t-1}m_t$, there is a high possibility that α_i (i = 1, ..., n') as a group may not be significant when the F-test is conducted. This means that the money stock does not cause real output in the sense of Granger. In this case, the LSW hypothesis corresponding to this model may be tested by Granger Causality between money stock and real income, indicating that the LSW proposition will be rejected if the money stock "causes" real output.

However, if the aggregate supply function is not the simple Lucas-type but rather the type Barro used in his empirical study, namely,

$$Y_t = \sum_{i=1}^{n} \lambda_i Y_{t-i} + \sum_{i=1}^{n} \beta_i (m_{t-i} - E_{t-i-1} m_{t-i}) + u_t,$$

the estimated value of α_i will be biased when Equation (13) is estimated because the past value of m_t contains information concerning $m_{t-i} - E_{t-i-1}\, m_{t-i}$ (i = 1, ..., n'). Thus it is not possible to judge the acceptance or rejection of the LSW proposition from the results of the Granger Causality test.

Moreover, since there will also be bias even in the simple Lucas-type supply function if there is a serial correlation in u_t, a problem will arise if the Granger Causality is used in verifying the LSW proposition. This is the problem that arose when Hamada and Hayashi (1985) tried to interpret the Granger Causality between income and money stock from the reduced form equation formulated by Barro. Hamada and Hayashi (1985)'s way of thinking is explained as follows: The output equation formulated by Barro,

$$y_t = \sum_{i=1}^{n} b_i (Dm_t - E_{t-1} Dm_t) + u_t,$$

(where D is a difference operator i.e. $DX_t = X_t - X_{t-1}$)
is rewritten using the function of the lag operator

$$b(L) = b_0 + b_1 L + b_2 L^2 + \dots ,$$

$$y_t = b\,(L)\,(Dm_t - E_{t-1}Dm_t) + u_t\ .$$

If $b(L)^{-1}$ is multiplied by both sides of the equation,

$$b(L)^{-1} y_t = (Dm_t - E_{t-1}Dm_t) + b(L)^{-1} u_t\ .$$

This may further be rewritten,

$$y_t = a(Dm_t - E_{t-1}Dm_t) + \sum_{i=1}^{\infty} f_i y_{t-i} + w_t.$$

If $w_t = b(L)^{-1}\, u_t$ happened to be a white noise,

$$y_t = \sum_{i=1}^{T} f_i y_{t-i} + \sum_{i=1}^{T} g_i Dm_{t-1} + v_t,$$

is estimated, but the Dm_{t-i} coefficient g_i is likely to be insignificant as a group (Dm_t does not cause Y_t in the sense of Granger). However, the assumption that the w_t obtained by multiplying $b(L)^{-1}$ which determines the relationship between money stock and income in the equation, has by chance turned into a white noise, must be regarded as untenable. Thus it would be more natural to regard the testing of the LSW proposition by Granger Causality as inseparable from the formulation corresponding to the simple Lucas-type supply function.[11]

6. Chi-square Test of the LSW Proposition Using Likelihood Ratio — Method in Mishkin (1983) and Studies by Gochoco (1986) —

In his series of studies (Mishkin (1982a), (1982b), and (1983)), Mishkin proposed a likelihood ratio test utilizing cross equation restrictions as an efficient procedure for testing the LSW proposition.

The empirical results concerning the U.S. economy obtained by Mishkin are:
(1) Anticipated in money stock influence real output, indicating that the LSW proposition is rejected so long as the hypothesis of *a priori* identification is proved to be correct.
(2) Looking at the rational expectations hypothesis and the proposition of neutrality of money separately, while the proposition of neutrality of money is strongly rejected, the empirical results concerning the rational expectations hypothesis are ambiguous, and thus the LSW proposition as a joint hypothesis is rejected principally by the neutrality proposition.

Using both seasonally-adjusted and seasonally-unadjusted data, Gochoco (1986) applies Mishkin's method to Japanese economy under the floating exchange rate system (Table 15). As a result, Gochoco concludes that the LSW proposition as a joint hypothesis and the proposition of neutrality of money are rejected (that is to say, that anticipated changes in money stock exert influence on real outcome), while the rational expectations hypothesis is not.[12]

11. Another problem that may be cited is the fact that the lag length of real output, which in a model is essentially infinite, is cut off at the appropriate length T. The fact that the results of Granger test are extremely sensitive to the selection of the lag length. Thornton and Batten (1985), checked the Granger Causality between nominal income and various money stock indices using a large number of different lag lengths, confirmed this point.

12. With regard to the money supply forecasting equation, the rate of growth of M_2 + CD was regressed on its lag value as well as its WPI domestic goods and mining and industrial production (both with a 6-quarter lag). (The current account balance, the *gensaki bond* repurchase agreement rate, and the rate of financial deficits were not included since these were not significant.)

Table 15 Output Equation by Gochoco (1986)

Estimate Model: $\text{LogIPI}_t = C + \text{TREND} + \sum_{i=0}^{11} \beta_i (M_{t-i} - M^e_{t-i}) + \sum_{i=0}^{11} \delta_i (M^e_{t-i}) + \rho e_{t-1} + \eta_t$

Explanatory Variable	Using Seasonally-adjusted data		Using Seasonally-unadjusted data	
C	4.1560	(0.1894)**	3.7618	(0.1782)**
β_0	0.5853	(0.3848)	1.0483	(0.5400)
β_1	−8.9086	(5.4605)*	0.3333	(0.7691)
β_2	−5.7596	(5.3670)	1.3803	(0.8143)*
β_3	0.8392	(4.8038)	2.2187	(0.9379)**
β_4	7.6414	(6.0260)	2.2931	(1.1382)**
β_5	17.9122	(10.5813)*	2.2073	(1.2303)
β_6	16.6555	(10.0083)*	0.3470	(1.2931)
β_7	8.0305	(6.4279)	−0.4363	(1.5001)
β_8	2.3072	(3.6410)	−1.2257	(1.7651)
β_9	−3.3621	(2.8959)	1.6433	(1.8126)
β_{10}	−4.6979	(3.0701)	2.6577	(1.6619)
β_{11}	−0.1739	(1.6716)	4.7692	(1.3624)**
δ_0	9.2672	(5.1703)*	3.3102	(0.8655)**
δ_1	−4.3316	(4.2666)	3.1097	(1.4467)**
δ_2	−7.9298	(5.1613)	4.2317	(1.9238)**
δ_3	−4.5351	(3.8100)	3.8597	(2.1733)*
δ_4	−8.2899	(5.9207)	2.4411	(2.3021)
δ_5	4.5807	(4.5526)	1.5111	(2.5581)
δ_6	9.5874	(5.6517)*	1.8140	(2.8853)
δ_7	4.2649	(4.3963)	5.8769	(3.2227)*
δ_8	3.8061	(3.5025)	5.0418	(3.2415)
δ_9	−0.6088	(2.6207)	8.0000	(2.9292)**
δ_{10}	−6.0108	(3.7620)	6.8929	(2.2920)**
δ_{11}	1.5255	(2.9386)	6.4484	(1.5721)**
TREND	0.0042	(0.0006)**	0.0037	(0.0006)**
ρ	0.8961	(0.0459)*	0.8662	(0.0587)**
R^2	0.9941		0.9923	
MSE	0.0132		0.0239	
Likelihood ratio test results				
LSW Proposition	55.58** (0.0001)		122.21** (0)	
Neutrality proposition	41.95** (0.0018)		120.78** (0)	
Rational expectations hypothesis	13.63 (0.8049)		1.551 (0.99)	

Notes:
- Log IPI : Month-to-month growth rate (%) of industrial production
- C : Fixed number
- TREND : Primary trend
- M : Month-to-month growth rate (%) of M_2 + CD
- M^e : Anticipated value of M_2 + CD

Sample period: 1973-1984 (monthly)
MSE : Mean squared error
Figures in parentheses of output equation are standard deviations
* : Significant at the 5% level
** : Significant at the 1% level

In likelihood ratio test, upper row figures are likelihood ratio. Numbers in parentheses are levels of marginal significance.

Gochoco's empirical results, like Mishkin's (1983) empirical results in the United States, suggest that the LSW proposition is not accepted,[13] and that the main reason is that the neutrality proposition is not established. Furthermore, in contrast to Parkin's prediction, the robustness of these results is high as far as the treatment of seasonality is concerned.

III. Conclusion — Future Problems

This paper has introduced the general outline of empirical results of studies carried out thus far applying the LSW proposition to the Japanese economy. These results are summarized in Table 16. Both Barro-type and Mishkin-type of empirical

Table 16 Comparison of Empirical Test Results of LSW Proposition on Japanese Economy

	Method	Sample period and data attributes	Acceptance/ rejection of LSW proposition	Features
Pigott (1978)	Barro-type	Seasonally-adjusted, quarterly (1958: I-1977: III)	Rejection	Imposes severe limitation on output equation. Money stock forcasting equation is low in accuracy.
Seo and Takahashi (1982)	Same as above	Seasonally-adjusted, quarterly (1961: I - 1980: IV)	Rejection	Formulates money supply forecast equation as policy response function.
Hamada and Hayashi (1985)	Barro and Granger test	Seasonally-adjusted, monthly (Oct. 1965 - Dec. 1982)	Rejection	Uses monthly data. Empirically tests the exogeneity of error.
Gochoco (1986)	Mishikin-type	Seasonally-adjusted and seasonally-unadjusted monthly (1973: I - 1984: III)	Rejection	Applies simultaneous estimation method. Tests influence of seasonally adjustment.
Taniuchi (1982)	Barro-type	Seasonally-adjusted, quarterly (1960: IV - 1980: II)	Rejection	Formulates prior expectations model based on "Shunto."
Parkin (1984)	Granger test	Seasonally-adjusted quarterly and seasonally-unadjusted quarterly (1967: I - 1982: I)	Acceptance	Tests influence of seasonal adjustment.

13. However, in Mishkin's study, the conclusion varies greatly depending on the length of the lag in the output equation: if the lag is reduced to 7 quarters, the LSW proposition is accepted; if it is extended to 20 quarters, the proposition is rejected. By contract, Gochoco (1985) rejected the LSW proposition even if the lag is relatively short.

results suggest that the LSW proposition is not established in Japan. Parkin's rebuttal seems to lie on shaky ground.

Methodologically speaking, however, problems still remain. Following are substantial problems that have not been adequately taken up thus far.

Methodologically speaking, however, problems still remain. Following are of problems that have not been adequately taken up thus far.

1. Problem of Information Set at the Time of Expectation Formation

The Barro/Mishkin-type of method so far assumes that the economic agent has information at the beginning of the period of estimation that in fact can only be gained at the end of the period of measurement.

Barro (1977) reports that the empirical influence of this assumption is minor. On the other hand, Sheehan (1985) reports that the empirical results of the LSW proposition depend heavily on the hypothesis concerning the formation of expectations, so that if excessive information set were assumed, the empirical results would tend to be advantageous to the LSW proposition in the case of the United States.

This is a problem that should be examined in the future even for the Japanese economy.[14]

2. Problem of Degree of Freedom

With regard to the Barro-type tests of the LSW proposition, a problem that has not been discussed very much is that involving the lack of degree of freedom in estimating equations. What is problematic here is that since the series of studies Barro, the normal practice has been to treat each lag value, of explanatory variable as an independent variable. As a result, it cannot be denied that multicolinearity has developed among explanatory variables, thus rendering the estimatioin results unstable. In fact, Takahashi explains, based on his experience with this form of estimation, that the results of estimation are changed considerably by changing the length and formulation of the lag. Thus it can be said that there is room for checking the robustness of the coefficient values.[15]

14. We may site Meltzer (1985) as an attempt in this direction. Meltzer compares the economic performance under the fixed exchange rate system with that under the floating exchange rate system by calculating forecast errors using the multi-stage Kalman filter and only the information available up to the forecast period. On the basis of this calculation, Meltzer measures the VAR models for prices, money stock, and real output.

15. Of course, in Parkin (1984), the Koyck lag is hypothesized for the aggregated supply function, while in Pigott (1978), the sum of the hypothesized as zero.

3. Problem of Observational Equivalence

The problem of observational equivalence, which has been raised by Sargent (1976) and others, is the most fundamental criticism of Barro's testing procedure.

Since it is in principle impossible to directly check the acceptance or rejection of the LSW proposition only from a reduced form equation, it means that the structural model and its identification conditions cannot help but be hypothesized *a priori.*

In this regard, Mishkin (1983) indicates[16] that the models are identifiable and that it is possible to hypothetically test the LSW proposition under the system

$$X_t = \sum_{i=1}^{M} Z_{t-i}\gamma_i + u_t,$$

$$Y_t = \tilde{Y}_t + \sum_{j=0}^{N}(X_{t-j} - \sum_{i=1}^{M} Z_{t-j-i}\gamma_i)\beta_i + \sum_{j=0}^{N}(\sum_{i=0}^{M} Z_{t-j-i}\gamma_i^*)\delta_i + \varepsilon_t,$$

where

X_t : a vector ($k \geqq 1$) of k variables including money stock,
Y_t : real output,
$\tilde{Y}_t$: output corresponding to natural rate of unemployment,
Z_{t-i} : a vector of p + k variables at $t-i$ quarter used for forecasting X_t ,
γ_i, γ_i^*, β_i, δ_i : coefficient matrix or vector

formed by generalizing the Barro-type models, one or the other of the following conditions is met:

i) Like the simple Lucas-type aggregate supply, the effect of unanticipated changes in X_t on real output should not be accompanied by a lag.

ii) At least one variable without direct influence on output should be included among the explanatory variables contained in the money supply forecast equation.

Furthermore, Buiter (1983) points out that, if it is hypothesized that the monetary authorities have adopted a policy rule that aims to neutralize (or accommodate) changes in unanticipated real output, the problem of inability to identify the relevant functions may arise. That is, under the above-mentioned policy rule, the money supply forecast equation is a function of changes in unanticipated real income ($Y_t - E_{t-1}Y_t$). For example,

$$m_t = aX_t + b(Y_t - E_{t-1}Y_t) + cY_t + u_t .$$

16. See Mishkin (1983) pp.13-15, pp.27-31 for details on this point.

This sort of situation may also occur depending on the response of the private banking sector.[17]

If it is assumed that the monetary authorities or the private sector are changing the money stock in accordance with unanticipated real income, it will become impossible to distinguish between the route in which changes in real output themselves exert influence autoregressively and the route in which unanticipated changes in real output are fed back to real output through the medium of unanticipated changes in the money stock. In this case, neither the test based on the reduced form equation formulated by Barro and Mishkin nor the test using Granger Causality is accepted.

This means that, regardless of the particular test procedure employed, the checking of policy rules by Seo and Takahashi (1981) and others, and also the checking of the private sector's reaction constitute an extremely important step in the empirical research procedure. Moreover, whether or not one can successfully eliminate the unanticipated real income fluctuation term in the money supply forecast equation will depend on the type of index one selects as a money supply concept, as well as on the unit period one adopts.

4. Function of Price

The narrowly-defined LSW proposition is a joint hypothesis consisting of

A) Lucas-type aggregate supply function,

B) rational expectations, and

C) monetarist aggregate demand function.

The reason that changes in the (unanticipated) money stock in this set up influence real output is that these changes bring about unexpected price changes through C). In other words, there are two links constituting the necessary condition for the establishment of the LSW proposition: the link between changes in the money supply and changes in price, and that between changes in price and changes in real output.

However, since Barro's approach ingeniously eliminates the price variable, it only has to examine the relationship between money stock and real output without considering the role of the price. This is the reason that, even if the relationship between real outcome and money stock under this empirical framework was consistent with the LSW proposition, one could not help but suspect that the relationship is real.

17. Buiter (1983) also points out that the reduced form of output equation formulated by Barro does not consider the effects on real income of anticipated future changes in the present and past money stock.

Therefore, it can be argued that it is at all costs necessary to test the link function of price to complement the empirical examination of the LSW proposition. Although the use of a multivariate time series model and other steps might naturally be considered a concrete method of conducting such a test,[18] it is also possible to approach this problem from the viewpoint of a reduced form price function.

Gordon (1982)'s study is an example of this way of thinking. In addition to estimating reduced form for price that expresses both the long-term neutrality of money stock and the possibility of gradual price adjustment,[19]

$$\dot{P}_t = \sum_{i=1}^{n} c_i P_{t-i} + d_0 E_{t-1}(\dot{Q}_t - \dot{\tilde{Y}}_t) + d_1(\dot{Q}_t - E_{t-1}\dot{Q}_t) + d_2 y_t + d_3 Z_t + u_t,$$

where

$\dot{P}_t$: the inflation rate at t,
$\dot{Q}_t$: the rate of growth of real GNP,
$\dot{\tilde{Y}}_t$: the rate of growth of natural output,
Z_t : the proxy for supply shock,
y_t : $Y_t - \tilde{Y}_t$,
u_t : white noise.

Gordon (1982) indicates that, if Lucas-Parkin type of aggregate supply function

$$y_t = \alpha(P_t - E_{t-1}P_t) + \lambda y_{t-1} + \varepsilon_t ,$$

is correct, the price equation will be

$$\dot{P}_t = E_{t-1}(\dot{Q}_t - \dot{\tilde{Y}}_t) + \frac{1}{1+\alpha}(\dot{Q}_t - E_{t-1}\dot{Q}_t) + (1-\lambda)y_t - \frac{1}{1+\alpha}\varepsilon_t.$$

In other words, in order for the LSW proposition to be established under Lucas-Parkin model of aggregate supply function, the following conditions should be satisfied.

$$\sum_{i=1}^{n} c_i = 0,\ d_0 = 1,\ d_1 = \frac{1}{1+\alpha} < 1,\ d_2 = (1-\lambda) < 1.$$

18. An example of tests of the LSW proposition using a multivariate time series model is found in the study conducted by McGee and Stasiak (1985). McGee and Stasiak rejects the LSW proposition, for it entails applying to the United States a trivariate time series model that uses logarithmic differences among price (GNP deflator), real GNP, and money supply.

19. What is noteworthy in these equations is the treatment of output corresponding to the conventional notion of the natural unemployment rate. Studies on the LSW proposition up to now have hypothesized that output corresponding to the natural unemployment rate is the primary (or secondary) exogenous trend (with a refraction that takes into account structural changes caused by the First Oil Crisis). Nevertheless, since it is theoretically possible that monetary and fiscal policies may cause changes in the output level corresponding to the natural rate of unemplyment, it cannot be denied that the above hypothesis is extremely convincing.

Here, $\Sigma c_i = 0$ signifies that price inertia is small, while $d_o = 1$ signifies that the price adjustment vis-à-vis demand is very fast.

Gordon (1982), after carrying out the tests of various lengths based on quarterly data on the U.S. economy from 1890 to 1980, reports his finding that price inertia was very large during this period (in this case, the LSW proposition is rejected).

Judging from the experience of the studies in the U.S., the points taken up in this section may prove to be a further disadvantage to the LSW proposition. However, they will be useful in deepening our understanding of the functional features of the Japanese economy.

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