Monetary Policy and Real Output in Korea : Some Tests of a Rational Expectations Approach

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I. Introduction

In recent years the "New Classical" approach, which incorporates features of the natural rate hypothesis and the rational expectations hypothesis in macroeconomic models, has led to the key propositions about stabilization policy, which can be summarized as follows : (i) Anticipated movements in nominal variables will have no real effects. Unanticipated changes do affect real output, but stochastic variations of policy variables merely raise cyclical output fluctuations. (ii) Countercyclical monetary policy changes, for example, are ineffective in stabilizing real output.[1] This equilibrium business cycle approach has been developed in stuies such as Lucas(1972, 1973), Sargent and Wallace(1975), and Barro(1976)and others.[2]

In view of its profound policy implications, one deterministic policy rule should be pursued. Thus, the empirical validity of policy ineffectiveness proposition is perhaps an important issue in new classical macroeconomics. In this sense, Barro (1977, 1978), Barro and Rush (1980) and others have provided empirical support for the neutrality hypothesis that only unanticipated money growth matters.[3] Recently, however, Frydman and Rappoport (1985) cast some doubt on Barro's and Mishkin's procedure in the face of the investigator's error in measuring rational expectations. They find that the anticipated and unanticipated distinction of money growth is irelewvant in explaining the movents of real autput.

Curiously almost all formal testing has been focused upon the United States. It is the purpose of this chapter to investigate for Korea the

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effects of unanticipated and anticipated mony growth on real output over the quarterly period 1961:I through 1983:IV

The chapter is organized as follows. Section 1 briefly outlines the procedure to specify a forecasting equation for money growth as a policy instrument. The empirical results of unanticipated and anticipated movements in the money growth rates on real output are then presented in the next section. Frydman and Rappoport's critique follows in the section 3. A summary and some concluding remarks are provided in the final section.

II. Specification of the Money Growth Equation

The measure of money stock used in this chapter is the narrow definition of money (currency plus checkable deposits). Ml growth is chosen (instead of M2 growth) on the ground that, over the period of estimation, there have been no substantial shifts in the preferences of liquid asset holders in Korea.

Money growth must be specified so as to make the hypothetical distinction between unanticipated and anticipated components empirically meaninful. A number of potential strategies are available for specifying a forecasting model for money growth. Without loss of generality at least four strategies are here considered. First, current information for the relevant predictors should be omitted from the forecasting equation since only information at time t-1 is known when expectations are formed at time t. Second, the variables employed as predictors of money growth should also explain a sizable proportion of the total variation in the dependent variable. Third, the forecast errors from the regression equation (which are tracted as a proxy for the unanticipated component in output equation) should be serially uncorrelated and also uncorrelated with some set of information available at the time the forecast is made. Finally, an econometric relationship should remain stable in order to postulate that agents had common knowledge about the structure of the equation.[4]

In addition, in determining relevent predictors of money growth and their lag specifications, the objective was basically to estimate a well-fitting money growth equation with a white noise error process. This procedure is used to specify a forecasting model for Korean money growth. Money growth depends on an essential manner on its own five quarterly lag values as well as the growth rate of central govermnent expenditure.

Using the quarterly data covering the period 1961: I to 1983:IV, we estimated the money growth (MIG) equation by Ordinary Least Squares (OLS). The results obtained are as follows:

$$M1G=0.069+0.662M1G_t-1+0.134M1G_t-2-0.028M1G_t-3-$$
$$(2.350)\ (6.46)\qquad (1.145)\qquad (0.242)$$
$$0.388M1G_t-4+0.238M1Gt-5+0.135G_t$$
$$(3.527)\qquad (2.559)\qquad (2.679)$$
$$\bar{R}^2=0.573\ \ F=21.106\ \ DW=1.907\ \ Q(24)=23.00 \qquad (1)$$

where

$M1G_t$=the quarterly rate of growth of Ml definition,

G_t=the quarterly growth rate of government expenditure,

F=the F-statistic,

DW=the Durbin-Watson statistic

Q=the Box and Pierce Q-statistic.

The absolute values of t-statistic appear in the parentheses below the coefficient estimates. The set of independent variables explained a sizable and significant proportion of the total variation in the money growth rate. On the other hand, an F-value for the joint hypothesis that the G coefficient is zero is $F^1_{85}=9.88$, which is significant at the 0.2 percent level. Efficient estimates and correct test statistics depend on the absence of significant serial correlation. To check for serial correlation, the Durbin-Watson statistic and the Q-statistic for the first twenty-four autocorrelations are presented.[5)] The Q statistic, which is approximately chisquare distributed, has a value of 23.00. Its corresponding P-value is 0.520, which means that there is a 52 percent chance that the residuals come from a white noise series. The reported Q statistic, therefore, suggests that the hypothesis that the first 24 autocorrelations are zero could not be rejected. A 57 percent of the total variation in the money growth rate was explained by the equation. Finally, the structural stability of the equation was examined by Chow tests. With two subperiods of the data the Chow test result indicated that the hypothesis of structural stability would be accepted at the 25 percent level.[6]

Based on some evidence for adequacy of the forecasting model, we now proceed to using these estimates for testing the policy ineffectiveness proposition that fluctuations of output around the natural level depend only on unancipated money growth.

Ⅲ. Anticipated/Unanticipated Money Growth and Real Output

The procedure employed here to investigate the effects of unanticipated and anticipated movements in money growth on real output is basically similar to those of Barro and Rush(1983) and Mishkin(1983). As seen in their framework, it is a key issue to decompose appropriately the money growth rate into unanticipated and anticipated parts.[7] As a proxy, these variables are represented respectively by fitted values and residuals from the forecasting equation(1). Using these components we shall estimate the following reduced form output equation and test for the statistical significance of the coefficients. For convenience, equation(1) can be slightly modified as

$$M1G_t = Z_{t-1}\delta + v_t. \qquad (2)$$

The tests here are based on the macro Rational Espectations model of th form

$$y_t = y_{nt} + \Sigma^{j}_{i=0} Bi(M1G_t - Z_{t-1}\hat{\delta}) + \Sigma^{j}_{1=0} y_i Z_{t-1}\hat{\delta} + u_t \qquad (3)$$

$$u_t = \Sigma^{k}_{i=0}\ \rho_i u_{t-i} + \varepsilon_t \qquad (4)$$

where

$M1G_t$=the M1 growth rate,

Z_{t-1}=a vector of predictors used to forecast M1G which are known at time t,

δ=a Vector of coefficients,

V_t=an unpredictable shock which is assumed to be uncorrelated with some set of information available at time t and also serially uncorrelated,

y_t=the natural log of real output (GNP),

β_i=a vector of coefficients,

y_i=a vector of coefficients,

U_t=a stochastic error term which is assumed to be serially correlated,

p_i=autoregressive coefficients,

ε_t=a white noise error term.

The regression cannot be carried out until a proxy is found for the natural rate of output. As to natural level of output, a proxy is assumed to be a constant and linear time trend.[8] According to equilibrium models of the business cycle, any deviation of output from the natural rate is represented by a serially uncorrelated stochastic process with mean zero.[9] However, it is hard to explain the observed persistent movements in output and unemployent with the models. Hence, for empirical work rather than any theoretical justification, lag values of u_t term in equation (3) are simply added to the natural rate so that the natural rate of output is shown to be itself serially correlated. Thus, the natural rate can be specified as follows :

$$y^k_{nt}=C+\ \tau\,\mathrm{TIME}+\sum_{i=0}^{K}\rho_i u_{t-1}. \tag{5}$$

A two-teop procedure was used in estimating equations(3) and (4). The first step is to estimate equation (2) by OLS. The results are reported in the previous section. This step decomposes actual money growth M1G into $M1G_t$-$Z_{t-1}\hat{\delta}$ and$Z_{t-1}\hat{\delta}$. Substituting these components into equation(3. 3), the second step is to estimate equations(3. 3) and (3. 4) jointly.

In the second step equation (3) is estimated using the Almon polynomial distributed lag.[10] Since we have to specify a priori the choice of the length of lag and the degree of the polynomial, several important decisions had to be made. The first decision concerns the length of lags on the policy variables —— the size of J in equation (3). As in Barro(1977, 1978) and Barro and Rush (1980), one possibility for specifying the length of lag is to keep on extending the length of lag until the coefficient of additional lag variable is no longer statistically significant. On the basis of such a criterion, 7 lags of each variables were empirically appropriate for Korean data.

The second decision is also to specify a priori the degree of the polynomial, we used a quadratic polynomial for lag coefficients, while Mishkin used a fourth-degree polyomial lag. However, in contrast to Mishkin, end ponint constraints were not imposed, as recommended by Schmidt and Waud (1973), in order to avoid a potenteal bias. The final decision made concerned the determination of K, the order of potential serial correlation in the reduced form output equation. We used a second-order autoregressive process since the third autoregressive coefficient did not appear to be sizable of significant when added to equation (3).[11]It is found for Korean data that the selection of a second-degree polynomial for seven lag coefficients and of a second-order autoregressive process resulted in the highest value of R^2 of the coefficient of determination adjusted for the number of degrees of freedom.[12]

Table 1. Effects of Unanticpated and Anticipated Money Growth on Real Output

$c=7.1555$ (152.26)**	$r=0.0212$ (95.51)**
$\rho_1=0.5054$ (4.51)**	$\rho_2=0.4055$ (3.57)**
$\beta_0=0.0647$ (1.91)*	$r_0=0.1148$ (2.77)**
$\beta_1=-0.0064$ (0.22)	$r^1=0.1356$ (4.91)**
$\beta_2=-0.0607$ (1.75)	$r_2=0.1481$ (6.04)**
$\beta_3=-0.0981$ (2.55)**	$r_3=0.1514$ (5.87)**
$\beta_4=-0.1186$ (3.11)**	$r_4=0.1457$ (5.69)**
$\beta_5=-0.1222$ (3.48)**	$r_5=0.1308$ (5.86)*
$\beta_6=-0.1090$ (2.98)**	$r_6=0.1068$ (5.62)**
$\beta_7=-0.0788$ (1.53)	$r_7=0.0736$ (2.91)**

$\bar{R}^2=0.996$ $F=1896.4$ $DW=1.967$ ρ —value of $Q(24)=0.875$

Note : The absolute values of t-statistics appear in the parentheses.

* significant at the 5 percent level.

** sigificant at the 1 percent level.

The regression results obtained are displayed in Table 1.

Note that additional lag values of anticipated and unanticipated parts are shown to be insigificant when added to the output equation. the residuals from the estimated output equation do not show any significant pattern of further serial correlation with the Durbin-Watson statistic of 1967. In addition, a ρ-value for Box and Pierce test indicates that there is a 88 percent chance for the first 24 autocorrelations are a white noise series. The output equation explained a 99.6 percent of the total variation in the real output. The effect of a time trend appears to be significant, and the coefficient estimate of 0.021 amounts to about 3 times that of 0.008 reported in Mishkin's study for the United States.

Contrary to the results for the United States, both anticipated and unanaticipated money growth movements Have significant effects on the short-run behavior of real output. The pattern of the unanticipated part has a positive contemporaneous response but negative persisting responses. The sum of impact effects of unanticipated movements is negative, which is contrary to what might be expected. While the total effects of the anticipated component are, as espected, positive. An interesting result is that the anticipated part has positive, contemporaneous and persistent real effects. In sum, the empirical results presented here for Korea strongly reject the claim of the policy ineffctiveness proposition that only unanticipated policy shocks matter. We, therfore, infer that the neutrality hypothesis does not hold in Korea, rather the results obtained provide strong supprt for the Keynesian view that activist montary policy can play a significant role in determining the course of the business cycle.[13)]

Ⅳ. The Irrelevance of the Anticipated-Unanticipated Distinction for Real Output

Following Frydman and Rappoport's econometric critique(1985a, b) a measurement error of rational expectations, when investigator's information set is shorter than agents' inormation, casts doubt on the validity of the statistical inferences in the earlier secton. In this section the hypothesis of the "Irrelevance of the Anticipated and Unanticipated Distinction" (IAUD) will be tested in the context of Frydman and Rappoport's framework. Their framework is given by

$$y_t = \Sigma_{i=0}^{j} \beta_i (M1G_{t-1} - M1G_{t-1}^{re}) + \Sigma_{i=0}^{j} y_i M1G_{t-1}^{re} + y_{nt} + u_t \tag{7}$$

$$u_t = \Sigma_{t=0}^{k} \rho_i u_{t-1} + \epsilon_t \tag{8}$$

where $M1G_t^{re} = E(M1G_{t-1}^{11} \Phi_{t-1})$, is the agents' information set. To provide a proxy for $M1G^{re}$, investigator is supposed to forecast $M1G^{re}$ using the subset of agents' information, Φ_{t-1}.

$$M1G^{re}{}_t = z_{t-1}\delta + v_t \tag{9}$$

where v_t is the investigator's measurement error of rational expectations, which is contemporaneously orthogonal to Z_{t-1} by construction.

Substituting equation (9) into equation (7) yields

$$y_t = \Sigma_{i=0}^{j} \beta_i (M1G_{t-1} - Z_{t-1}) + \Sigma_{i=0}^{j} \gamma_i z_{t-1} \delta + y_{nt} + n_t \tag{10}$$

where $n_t = \Sigma_{i=0}^{j} (\gamma_i - \beta_i) v_t + u_t$. Since v_t is investigator's error in measuring rational expectations, this is, in gereral, orthogonal to z_{t-1}. Thus, unless $\gamma_i = \beta_i$ the estimated regression coefficients are inconsistent. Meanwhile, if $\gamma_i = \beta_i$ the term v_t would disappear from the output equation (10). This fact guarantees the validity of the statistical inferences on the estimation of the output equation (10).

The hypothesis of the IAUD is

$$\underline{\gamma} = \underline{\beta} \tag{11}$$

where $\underline{\gamma} = (\gamma_0 \ \gamma_1 \cdots \gamma_j)'$, and $\underline{\beta} = (\beta_0 \ \beta_1 \cdots \beta_j)'$. Under IAUD, output depends only on the money growth rate, that is, it does not matter whether monetary policy is anticipated or unanticipated.

To implement a plausible test the trend stationary (TS) version of the output equation will be estimated.[14] In terms of polynomials in the lag operator L, the TS version of the output equation (10) is given by

$$y_t = \beta^*(L)(M1G_t - z_{t-1}\delta) + \gamma^*(L)(z_{t-1}\delta + \alpha_0^* + \alpha_1^* t + \rho(L) y_t + n_t \tag{12}$$

where $a_0^* = \alpha_0(1 - \rho(L))$, $\alpha_1^* = \alpha_1(1 - \rho(L))$, and $n_t = (\gamma^*(L) - \beta^*(L)) v_t + e_t$. Equation (12) is the '$\rho$—differenced' version of the output equation to eliminate the serial correlation of the error term u_t. Since K=2, the length of the lag actually employed in estimation is $J^* = j + 2$.

A two—step procedure is used in estimating equation(12).[15] to provide an estimated proxy for $M1G_t^{re}$; $M\hat{1}G^{re}=z_{t-1}\hat{\delta}$ where $\hat{\delta}$ is the OLS estimator of δ. This proxy is substituted for $z_{t-1}\delta$ in equation (12). The second step is then to estimate B^* y^* by OLS.[16] The results of testing the IAUD hypothesis are shown in Table 2. It is observed that the distinction between output effects of anticipated and unanticipated money growth are statistically irrelevant in explaining the movements of aggregate output. Thus, the results can provide empirical support for Frydman and Rappoport's IAUD hypohtesis.

If the IAUD hypothesis is valid, the output equation (10) may be rewritten as

$$y_t = \Sigma^j_{i=0} \tau^i M1G_{t-i} + y_{nt} + u_t \quad (13)$$

or, as in the DS specification,

$$(1-L)y_t = \Sigma^j_{i=0} \tau_i (1-L) M1G_{t-1} + u_t \quad (14)$$

where $\tau_i = \beta_i = \gamma_i$.

Table 2. P—Values for F—Tests

No. of Lags(J)	$\tau^* = B^*$	$\gamma^*_8 = \cdots \gamma^*_j = B^*_8 = \cdots \beta^*_j = 0^a$
7	0.6895	
8	0.8039	0.2766
10	0.4414	0.2714
12	0.4014	0.1128
15	0.8668	0.1758

We estimated equation (14) by OLS and tested the hypotheses that $\sum_{i=0}^{J} \tau_i = 0$ and $\tau_i = (\tau_0 \cdots\cdots \tau_J) = 0$, for each J=7, 8, 10, 12, 15. Table 3 contains the results obtained. In all cases both hypotheses are strongly rejected. In particular, the empirical result that $\Sigma \tau_i \neq 0$ implies that a permanent change in the rate of money growth has a permanent effect on real output. We may infer that money in this framework is not "super-neutral".

V Concluding Remarks

This chapter has examined the important issue of whether the anticipated and unanticipated components of money growth matter for Korean over the quarterly period 1961 : I to 1983 : IV. We specified an equation to predict money growth. Anticipated movements of money growth were hypothesized as the fitted values from the forecasting equation, whereas the residuals were taken to represent the unanticipated part of money growth. The output equation was then specified in which anticipated and unanticipated money growth were treated as explanatory variables. A proxy for the natural level of output is also included as an additional influence on real output. The anticipated money is shown to have more significant real effect than the unanticipated money.

Table 3. P—Values for F—Tests

No. of Lags (J)	$\Sigma_i^j \tau_i=0$	$\tau_i=0$
7	0.0001	0.0001
8	0.0001	0.0001
10	0.0001	0.0001
10	0.0001	0.0001
15	0.0001	0.0001

The empirical results suggest that both components of money growth explain the movements of aggregate output. That is, the anticipated parts of money growth induce positive deviations of real output from the natural rate, whereas the unanticipated parts have nagative output effects which are contrary to what might be expected. We find that monetary policy, irrespective of whether it is anticipated or unanticipated, affects Korean output with anticipated movements having the significant effect. However, it is also found that the anticipated and unanticipated distinction does not matter for explaining the movements of real output in the face of the investigator's error in measuring rational expectations. A careful reconsideration of the money growth specification is motivated.

Appendix

The Data

The definitions and the sources of the data used in this chapter are as follows ;

M1G=quarterly growth rate (end of period) of M1 as percent changes to the same quarter of the previous year.

sources : The Bank of Korea, *Money and Banking Statistics,* 1984, and *Monthly Bulletin,* January 1986.

G=quarterly growth rate of government expenditure calculated by a log term.

Sources : International Monetary Fund, *Financial Statement,* 1961—1984.

y_t=real GNP (billion won 1980) adjusted seasonally.

Sources ; The Bank of Korea, *National Income,* 1974, and *Quarterly GNP(Basic year 1980),* unpublished, 1986.

Note : The quarterly real GNP data for period 1960 : I —1969 : IV are based on a 1970 constant price. Meanwhile, the data covering the period 1970 : I to 1983 : IV are based on a 1980 constant price. Therefore, the former data used here were transformed into real GNP series at a 1980 market price. Then the data for the entire sample period were adjusted seasonally by using a X11 computer program.

Footnotes

1) In the Lucas model where economic agents respond only to relative price movements and are spatially isolated, informational asymmetries cause them to confuse relative price movements with nominal price movements. Using rational expec tations in forming their price forecasts, any systematic component of price movements will be forecasted rationally in the sense of Muth (1961). Thus, the nature of the Lucas supply function insures that these anticipated price changes will not affect supply of output.
2) Howerer, equlibrium models of the business cycle could not explain the persistence of the typical business cycle, see Modigliani (1977). On the other hand, these theories focus only upon one of possible multiequilibrea of rational expectations. In this sense, other equilibria are typically not cnsidered. In some of them, output is positively correlated ; in others the correlation is negative. For a further elaboration of this important issue, see Farmer and Woodford (1984).
3) Leiderman (1980) provides strong support for the view that anticipated monetary policy has on real effects. However, Mishkin finds that his testing results are sensitive to the lag length used. When twenty lags are considered the neutrality hypothesis is rejected, while with seven lags used it is not.
4) In a macromodel where the main interest is on the effect of monetary policy on output, Lucas' criticism (1976) implies that changes in policy variables will result in changes in the behavioral relation in estimated models.
5) The Durbin-Watson statistic is known to be biased in the presence of a lagged dependent variable among the regressors.
6) Chow test is a typical form of F-test in which the stability of the regression coefficients over two subperiods of the data are tested. This is carried out by running the same

regression model for the two subperiods, and comparing the sums of squared residuals.

$$\text{Chow test}=[\frac{SSR_0-SSR_1}{SSR_1+SSR_2}]\ [\frac{T-2k}{k}]\sim\sim\sim F(k,\ T-2k)$$

where

SSR_0=the sum of squared residuals from the entire sample period regression (1961 : I to 1983 : IV),

SSR_1=the sum of squared residuals from the first sample period regression (1961 : I to1972 : II),

SSR_2=the sum of squared residuals from the second sample period regression (1972 : III to 1983 : IV),

SSR_2=the sum of squared residuals from the second sample period regression (1972 : III to 1983 : IV),

T=the number of total observations,

K=the number of coefficients to be estimated.

7) The forecasting equation (1) is assumed to be identified explicitly with agents' expectations of money growth rate.
However, some studies made an attempt to deal with a mismeasurement problem of rational expectations on the tests of hypotheses of the new classical macroeconomics. For more details, see Frydman and Rappoport (1985a, 1985b).
8) Barro and Mishkin used this tye of the nature rate of output.Techonolgical progress can be considered as another hypothetical determinant of the natural rate of output. Dornbusch and Fischer (1984) suggest that the use of labor productivity as a proxy for technological progress.
9) Because the only source of any deviation of output from the natural rate is a random forecast error, the time series of output must be uncorrelated. In other words, since a posetive forecast error at time t does not convey any information about the next forecast error, the guess for the next period's output stays still at the natural rate.
10) The least squares estimates are not sufficiently precise in the case of a high degree of multicollinearity in the regressor variables. As a result, most of the estimated regression coefficients might be statistically insignificant, and powerful inferences concerning the true weights would not be possible. In such a case, a solution to this problem is to in trocuce the Almon lag technique.
11) Mishkin (1983) used a fourth-order autoregressive process, while Barro and Rush set K at 2.
12) Such a technique may not be without defects, for the differences between several values of$\bar{R}^2$ may be very smal. Nevertheless, one or the other of these criteria, plus other considerations may help in choosing the "best" lag for the problems at hand.
13) The Korean results are consistent with the macroeconomic contracting models of Fischer (1977), Phelps and Taylor (1977), and Taylor (1979).
14) See Nelson and Plosser (1982). The difference stationary (DS) version of the output equation is
$$y_t=\beta^*(L)(M1G_t-z_{t-1}\delta)+\gamma^*(L)z_{t-1}\delta+[(1-\rho(L))]L+\rho(L)]y_t+n_t.$$
This version is not employed here because the coefficient of y_{t-3} on the right hand side is shown to be insignificant.
15) Under IAUD the two-step method yields also efficient estimates. See Frydman and Rappoport (1985a, b).
16) Note that B=y iff B*=y*. Thus, using the estimates of B* and r* the hypothesis of the IAUD can be tested.

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