韓國開發硏究
제29권 제2호(통권 제100호)

A Test on the Efficiency of Monetary Policy in Korea

Seonghoon Cho
(Assistant Professor, School of Economics, Yonsei University)
Hyeon-seung Huh
(Associate Professor, School of Economics, Yonsei University)
Hee Yeul Woo
(School of Economics, Yonsei University)

한국 통화정책의 효율성 검정

조 성 훈
(연세대학교 경제학부 조교수)
허 현 승
(연세대학교 경제학부 부교수)
우 희 열
(연세대학교 경제학부)

* Seonghoon Cho: (e-mail) sc719@yonsei.ac.kr, (address) 134, Shinchon-Dong, Seodaemun-Gu, School of Economics, Yonsei University
* Hyeon-seung Huh: (e-mail) hshuh@yonsei.ac.kr, (address) 134, Shinchon-Dong, Seodaemun-Gu, School of Economics, Yonsei University
* Hoo Yeul Woo: (e-mail) virudhaka@yonsei.ac.kr, (address) 134, Shinchon-Dong, Seodaemun-Gu, School of Economics, Yonsei University

• Key Word: Monetary Policy(통화정책), Open Economy(개방경제), Optimal Policy Rules(최적통화준칙)
• JEL code: C62, C63, D84
• Received: 2007. 10. 23 • Referee Process Started: 2007. 10. 25
• Referee Reports Completed: 2007. 11. 30

ABSTRACT

This paper evaluates the efficiency of monetary policy in Korea within the framework of interest rate feedback rules. For this, a small open macroeconomic model is constructed in a similar fashion to Ball (1999). The model is shown to capture key features of the Korean economy well. Using this estimated model, optimal instrument rules are derived for a set of different monetary policy objectives. Empirical results find that the actual monetary policy in the class of instrument rules was not very effective in stabilizing the output gap relative to inflation. However, seemingly successful inflation stabilization observed in the data are not consistent with the policy rules as the reaction of the interest rate to inflation is very low. It also appears that the central bank did not react right to movements in the real exchange rate. This paper offers some suggestions for the conduct of monetary policy in Korea.

본 논문은 이자율 준칙에 근거하여 한국의 통화정책의 효율성을 인플레이션과 산출갭의 상대적 안정성을 중심으로 경험적으로 검증하는 데 목적이 있다. 이를 위해 1991년 이후 한국의 주요 거시경제 변수를 설명할 수 있는 구조적 모형이 필요한데, 본고에서는 Ball(1999)의 모형과 유사한 소규모 개방경제모형을 도입한다. 모형의 추정결과, 한국 거시경제 변수를 비교적 잘 설명할 수 있음을 확인할 수 있었고 추정된 모형을 바탕으로 이자율 준칙의 범위 내에서 최적 통화정책을 도출하였다. 따라서 최적 이자율 준칙하에서의 인플레이션과 산출갭의 변동성을 실제 데이터와 비교할 수 있다. 실증적 분석의 결과, 중앙은행은 산출갭의 변동성보다 인플레이션의 변동성을 낮추는 데 상대적으로 더 효율적이었음을 알 수 있다. 이는 외환위기 이후 인플레이션이 실제 중앙은행의 목표범위 내에서 하락 안정세를 유지하였고 변동성도 상대적으로 크지 않았음을 고려해 볼 때 타당한 결과라고 해석할 수 있다. 그러나 최적 이자율 준칙과 비교해 볼 때 실제 추정된 이자율 준칙은 인플레이션에 대한 반응 정도가 매우 낮아 인플레이션의 안정성이 이자율 준칙이 효과적이었기 때문은 아닌 것으로 나타났다. 또한 인플레이션을 유발할 수 있는 실질환율 상승의 경우 이자율을 오히려 하락시킨 것으로 나타났는데, 이는 이론 및 최적 이자율 준칙과는 배치되는 결과이다.

Ⅰ. Introduction

Since the beginning of the 1990s, an increasing number of central banks have adopted the inflation targeting system. Price stability becomes the primary goal of monetary policy. Mishkin and Posen (1997) find that inflation targeting in Germany, New Zealand, Canada, and the UK proved to be effective in lowering inflation without causing significant adverse consequences for output. In 1998, Korea also adopted inflation targeting under the provision of the revised Bank of Korea Act. The Bank of Korea (BOK) is no longer to pursue the dual objectives of maintaining the stability of the value of money and strengthening the soundness of the banking system, and is now entrusted with the primary goal of price stability. The revised Act shares elements reminiscent of those in earlier inflation targeting countries. Kim (1999), Kim and Kim (1999), and Hoffmaister (2001) offer a detailed discussion on the inflation targeting system of Korea.

No doubt, the effectiveness of monetary policy becomes more important as a key requirement for pursuing inflation targets. There are several studies examining this issue for the case of Korea. However, most of them failed to take account of the fact that Korea is a small open economy. In some studies, the models were built under the assumption of closed economies, which should not be appealing (i.e. Oh, 1999; Lee, 2003; Nam, 2005). Others allowed for an openness of the Korean economy. Yet, they continued to assume a Taylor (1993) rule as the optimal monetary policy rule (i.e. Kim, 2002; Nam, 2002). The Taylor rule would be optimal only under certain conditions. In particular, Ball (1999) shows that for open economies, the Taylor rule is suboptimal unless it is modified in an important way. The main reason is that monetary policy affects the economy through exchange rate as well as interest rate channels.

The purpose of this paper is to evaluate the empirical efficiency of Korean monetary policy in an open-economy setting. Instead of employing full-fledged theoretical DSGE (Dynamic Stochastic General Equilibrium) models, we focus on the policy-oriented empirical models. The underlying model is similar to Ball (1999), which is an extension of Ball (1997) and Svensson (1997) to an open economy. It consists of an IS equation, a Phillips curve, a relation between exchange rates and interest rates, and a monetary policy rule.

While the DSGE model approach has a clear advantage over the empirical counterpart as it is not subject to Lucas Critique, it also has disadvantages. First, there is no single right DSGE model to capture the salient empirical features, leading to model uncertainties. Second, as Rudebusch and Svensson (1999) forcibly argue, the practical macro models used by central banks in advanced countries such as the MPS model of the US Fed are the large-scale empirical models although forward looking expectations are imposed partially on several sectors. Third, the empirical fit of data of forward looking model such as New-Keynesian Phillips curve or intertemporal IS equation are typically worse than those of empirical models. For example, Fuhrer (1997) examines empirical performance of two different Phillips curve and the backward looking autoregressive Phillips curve was not rejected against the forward looking counterpart. Finally, Taylor (1993) and Bomfim and Rudebusch (1997) argue that Rational Expectations may be unrealistic during the transition periods. This logic may apply to the Korean economy as it experienced a structural change after the financial crisis in late 1990s. For these reasons, we believe that the disadvantage of using the empirical but structural model is outweighed by disadvantages of employing DSGE models.

We also avoid using the completely atheoretical VAR approaches which are an another major strand in the literature analyzing monetary policy issues. This approach under the open economy models requires to estimate a larger number of parameters than that of the structural model. Given that the data is available only from 1991, the structural model is better fitted for our purpose and the VAR results will be used only to gauge the empirical fit of the structural model.

Upon estimating this model, an optimal monetary policy rule is derived, and is used as a metric for evaluating the effectiveness of monetary policy in a similar fashion to Rudebusch and Svensson (2001). They evaluate the efficiency of several instrument rules over the historical performance in terms of variances of output gap and inflation. It is difficult to interpret the discrepancy of actual data from those implied my the optimal rule as an evidence of the policy inefficiency because the model is subject to the Lucas Critique and the optimality is valid only in the class of instrument rules. However, the relative efficiency can be judged across their model and the present model, apart from the fact that these models suffer from the same problems mentioned above.

The implied optimal rule differs from the Taylor rule which many studies have assumed a priori. Notably, the exchange rate enters the right-hand side of the policy rule. This filters out temporary effects of the exchange rate on inflation, which may occur as the exchange rate returns to its long-run level. The idea is that such transitory fluctuations have no or little impact on medium- to long-term inflation prospects and should not affect policymakers' actions (see Bryan and Cecchetti, 1994; Ball, 1999).

Empirical results find that the actual monetary policy in the class of instrument rules was not very effective in stabilizing the output gap relative to inflation. In particular, the discrepancy of variance of the output gap and that implied by the optimal rule is much larger than the discrepancy in the case of inflation. This may reflect the moderation in both the level and variances of inflation observed since the financial crisis. Therefore, one may conclude that the monetary policy rule has been relatively effective in control of inflation fluctuation. However, the reaction to inflation in the estimated interest rate rule is quite small, implying that the moderation in the variances of inflation is not supported by the instrument rule. Finally, it also appears that the central bank did not react right to movements in the real exchange rate, contrary to the theoretical prediction.

The remainder of this paper is organized as follows. Section 2 develops a model and its empirical adequacy is examined. Section 3 derives an optimal policy rule in the model. Section 4 considers different objective functions of monetary policy. They are inflation targeting, equally weighted inflation and output gap targeting, and output gap targeting. The implied optimal rules are used to evaluate the efficiency of actual monetary policy. To the end, some policy implications are drawn for the conduct of monetary policy in Korea. Section 5 concludes the paper.

Ⅱ. The model

1. The model economy

The underlying model is due to Ball (1999) which studies monetary policy rules in an open economy. The evolution of the economy is represented by the following system.

$$\pi_t = \mu\pi_{t-1} + \alpha y_{t-1} + \gamma(e_{t-1} - e_{t-2}) + \epsilon_t^{AS} \tag{1}$$

$$y_t = \lambda_1 y_{t-1} + \lambda_2 y_{t-2} - \beta(i_{t-1} - \pi_{t-1}) + \delta e_{t-1} + \epsilon_t^{IS} \tag{2}$$

$$e_t = -\theta(i_t - \pi_t) + v_t \tag{3}$$

$$v_t = \rho v_{t-1} + \epsilon_t^e \tag{4}$$

where π_t is the inflation rate; y_t is the percentage gap between real output (q_t) and potential output (q_t^*), that is, $100(q_t - q_t^*)/q_t^*$; e_t is the log of the real exchange rate (a higher e means depreciation); i_t is the Call rate; and ϵ_t^{AS}, ϵ_t^{IS}, and ϵ_t^e are white noise disturbances. All parameters are positive, and all variables are measured as deviations from average levels.

Equation (1) is an open economy Phillips curve. Inflation depends on its own lag, a lagged output gap, a lagged change in the real exchange rate, and an aggregate supply shock. Equation (2) is an open economy IS curve. The output gap depends on its own lags, a lagged real interest rate, a lagged real exchange rate, and a demand shock. Equation (3) posits a link between the real interest rate and the real exchange rate. It captures the mechanism that a rise in the interest makes domestic assets more attractive, leading to an appreciation. Equation (4) assumes that shocks to the real exchange rate follow an AR(1) process in order to capture the observed persistence in the real exchange rate. While exogenous, this specification can avoid additional endogenous variables such as the foreign short term interest rate and additional behavioral equations for the foreign countries.

Although this model was originally designed for annual data, we apply to quarterly data with the following modifications. First, π_t is calculated as a simple moving average of the past four quarters. This construction controls seasonality which is extremely severe and irregular in the Korean data. In particular, even the de-seasonalized implicit GDP deflator and the implied inflation calculated by using the official de-seasonalized real and nominal GDP, the seasonality does not disappear. We also compute the inflation rates of GDP deflator and consumer price index by applying the standard techniques such as X-11 or X-12 ARIMA, but they do not eliminate the seasonality. To this end, we may use π_{t-1}, π_{t-1}, π_{t-2}, π_{t-3} as an additional explanatory variables in the model. However, a number of extra parameters must be added in this formulation. The moving average of inflation may be viewed as adding the lagged inflations with a restriction on the coefficients, in order to preserve the parsimony of parameters. Second, y_{t-2} is added in the IS equation to take account of short-run dynamics better. Third, v_t is allowed to be serially correlated. However, its underlying shock, ϵ_t^e, remains independent of the other two shocks. Finally, Ball (1999) calibrated the model using a set of base parameter values. Here, we estimate the model and analyze what the data speaks.

To complete the model requires a monetary policy rule. We first use an interest rate feedback rule that explains the historical conduct of monetary policy in Korea. Later, this policy rule is canvassed for its effectiveness by comparison to the optimal rule implied by Equations (1) through (4) in the model. The following historical monetary policy feedback rule is considered.

$$i_t = b_1\pi_t + b_2\pi_{t-1} + b_3 y_t + b_4 y_{t-1} + b_5 i_{t-1} + b_6 e_t + b_7 e_{t-1} + \epsilon_t^{MP} \tag{5}$$

As will be proven below, the optimal instrument rule is a restricted version of Equation (5) that satisfies the prescribed monetary policy objective. As Ball(1999) showed, the optimal interest rate rule would be a linear function of the state variables in the model, which includes the real exchange rate. Therefore, one may interpret Equation (5) as determining a linear combination of the interest rate and the exchange rate, which is often called a monetary condition index.

Since we focus on the dynamics of the model, we subtract constants in the model and estimate the model with demeaned data.

2. Estimation of the Model

The sample period runs from the first quarter of 1991 to the third quarter of 2006.[1] All data were obtained from the BOK website at http://www.bok.or.kr. As a proxy for the price level, we use the consumer price index and the rate of inflation is calculated using the CPI. The measure of real output is real GDP in 2000 prices. The series on potential output is produced by filtering real GDP through the Hodrick-Prescott filter. The nominal interest rate is the uncollateralized overnight Call rate which is the monetary policy instrument of the BOK. The real exchange rate is constructed using the nominal exchange rate between Korea and the U.S. and their respective CPIs.

The model is estimated using MLE equation by equation.[2] [3] The estimation

1 Data on the official Call rate is available from the first quarter of 1991.

results are given below.

$$\pi_t = 0.77\pi_{t-1} + 0.11y_{t-1} + 0.07(e_{t-1} - e_{t-2}) + \epsilon_t^{AS} \quad (1)'$$
$$(0.07) \quad (0.04) \quad (0.02) \quad [0.87]$$

$$y_t = 0.58y_{t-1} - 0.11y_{t-2} - 0.05(i_{t-1} - \pi_{t-1}) - 0.14e_{t-1} + \epsilon_t^{IS} \quad (2)'$$
$$(0.17) \quad (0.13) \quad (0.05) \quad (0.04) \quad [1.24]$$

$$e_t = 1.31(i_t - \pi_t) + v_t \quad (3)'$$
$$(0.38)$$

$$v_t = 0.86v_{t-1} + \epsilon_t^e \quad (4)'$$
$$(0.07) \quad [4.61]$$

$$i_t = 0.16\pi_t - 0.19\pi_{t-1} - 0.015y_t + 0.22y_{t-1} + 0.92i_{t-1} + 0.19e_t - \quad (5)'$$
$$(0.23) \quad (0.20) \quad (0.18) \quad (0.16) \quad (0.06) \quad (0.05)$$
$$0.19e_{t-1} + \epsilon_t^{MP}$$
$$(0.05) \quad [1.29]$$

Figures in parentheses are the standard errors of parameter estimates and those in squared brackets are the standard deviations of the disturbances.

α and β are the key parameters governing the monetary policy transmission channel to inflation and output gap. In Equations (1)' and (2)', they are estimated at 0.11 and 0.05 with expected signs. Their magnitudes are small, but this is common in the literature (see Cho and Moreno (2006) for example). The estimate of γ at 0.07 is also sensible as a depreciation of the real exchange rate leads to a higher inflation.

Meanwhile, Equation (3)' indicates that a rise in the real interest rate $(i_t - \pi_t)$ yields a real depreciation ($\hat{\theta} = -1.31$). This prediction is in contrast to the standard economic theory. Nevertheless, the finding is consistent with the historical observation of 1990s, which exhibits a positive correlation between real exchange rates and real interest rates. This relationship is particularly strong since the financial crisis. The correlation for the period of 97:Q4 to 06:Q3 is 0.89.[4] The positive relationship between the two variables also has a consequence on the IS curve. Contrary to the theory, the estimated equation (2)' implies that a real depreciation causes the output gap to fall ($\hat{\delta} = -0.14$). While this finding is puzzling, the negative coefficient, $\hat{\delta}$ may reflect the strong positive comovement between the real exchange rate and the real interest rate in equation (3)'.

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[2] We did not estimate the model jointly because the parameters in Equations (1), (2), (3) and (4) may be affected and distorted by an arbitrary monetary policy feedback rule.

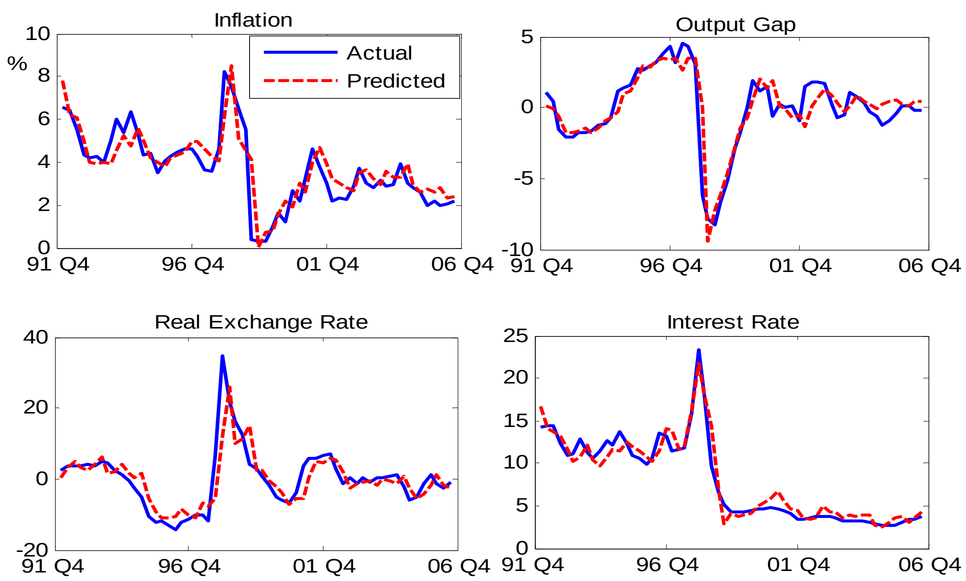
[3] Equation (3) and (4) are jointly estimated by eliminating v_t in (3) using (4) such that $e_t = \rho e_{t-1} - \theta[(i_t - \pi_t) - \rho(i_{t-1} - \pi_{t-1}) + \epsilon_t^e$.

[4] Two subsamples of 97:Q4 to 98:Q4 (financial crisis) and 99:Q1 to 06:Q3 (post-crisis) have their correlation coefficients at 0.95 and 0.20.

3. Fit of the Model

The model's empirical adequacy is examined in two ways. First, we examine how well the model predicts the economy. Figure 1 depicts model predictions and actual data. The historical and predicted paths moves closely together. The model also captures the structural break during the financial crisis well. To shed more light, Table 1 reports the variances of the variables under consideration. There is no substantial difference between actual data and the model predictions. One exception is that the model overestimates the variance of real exchange rates. We also evaluate the Root Mean Square Error (RMSE) of forecasts in our model relative to that of forecasts in the BOK04 model (a flagship model of the BOK) for the period of 2000:Q1 to 2003:Q4.[5] Table 2 shows that the former is smaller than the latter, pointing out some forecasting gains in favor of our model.[6]

[Figure 1] Model Prediction and Actual Data



Note: This Figure shows the actual (solid lines) and predicted (dashed lines) values for inflation, the output gap, the real exchange rate and the interest rate associated with the estimated model (1') through (5').

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5 The RMSE is calculated as $100\sqrt{\frac{1}{16}\sum(\frac{X^E - X^A}{X^A})^2}$, where X^E and X^A are forecasted and actual values, respectively. The BOK (Monthly Bulletin, 2005 May, p38) reports the RMSE of their forecasts only for the period of 2000:Q1 to 2003:Q4.

6 Note that the measure of inflation in our model is the average value over the past four quarters. This may help to reduce the RMSE of inflation.

<Table 1> Actual and Projected Variances of the Variables

	Var(π_t)	Var(y_t)	Var(e_t)	Var(i_t)
Data	4.27	7.04	66.53	27.41
Predicted	2.60	8.94	102.57	21.48

Note: This Table show the actual variance and the predicted variances implied by the estimated model (1') through (5').

<Table 2> RMSEs of the variables

	RMSE of π_t	RMSE of y_t
BOK04(SA)	0.43	0.76
MODEL	0.293	0.733

Note: The top row represents the figures of the root mean squared errors reported in Monthly Bulletin, p38, Bank of Korea, 2005. The bottom row show the RMSEs implied by the estimated model (1') through (5')

Second, we compare the impulse responses of our model to those obtained from a VAR. The VAR can summarize the general dynamics of the data and thus can provide a useful benchmark for the overall fit of a model. Our model can be viewed as a restricted specification from a four-variable VAR with two lags. Specifically, let $z_t = [\pi_t \; y_t \; e_t \; i_t]'$. Then, Equations (1) through (5) can be expressed in a matrix form:

$$A_0 z_t = B_{01} z_{t-1} + B_{02} z_{t-2} + \epsilon_t$$

This in turn produces the solution of the VAR(2) form as:

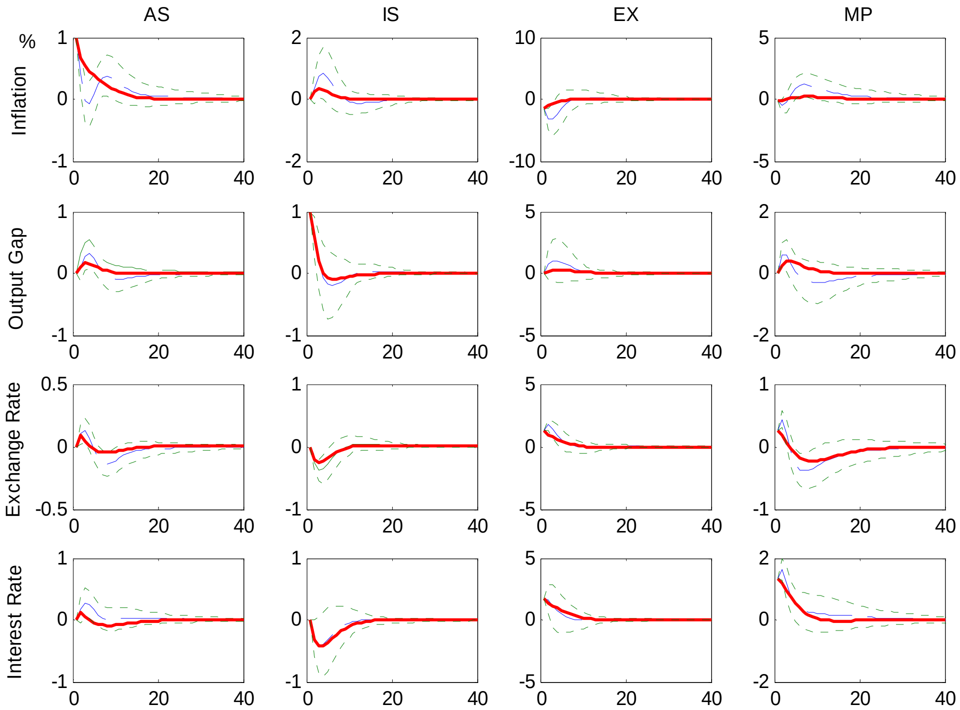
$$z_t = B_1 z_{t-1} + B_2 z_{t-2} + C\epsilon_t,$$

where $B_1 = CB_{01}$, $B_2 = CB_{02}$, and $C = A_0^{-1}$. Hence the model provides an identification restriction C on the coefficient matrix of the vector of the four structural shocks. The unrestricted VAR can be written as:

$$z_t = B_1^{UR} z_{t-1} + B_2^{UR} z_{t-2} + w_t$$

In order to compare the impulse responses of the two models to the structural shocks of the same size, we rewrite the innovations of the unrestricted VAR such that $w_t = C\epsilon_t$. We use this coefficient matrix C to compute the impulse responses of the four variables implied by the structural model and the unrestricted VAR to changes in one standard deviation of the four structural shocks. Figure 2 shows the results. The responses of the variables from our model are shown as thick lines. The corresponding figures from the VAR model are shown as dashed lines along with their 95% confidence intervals. All responses in

[Figure 2] Impulse Response



Note: This Figure presents the impulse responses of inflation, the output gap. the real exchange rate and the interest rate to the AS shock, IS shock, real exchange rate shock and the monetary policy shock. Solid lines and dashed lines represent the impulse responses which arise under the structural model and the unrestricted VAR (2), respectively. Dotted lines are the 95 % confidence intervals implied by VAR (2).

our model reside inside the VAR' s confidence intervals. This suggests that the restrictions do not greatly alter the dynamics of the model relative to an unrestricted VAR.

Ⅲ. The Optimal Monetary Policy Rule

This section derives an optimal monetary rule implied by Equations (1) to (4) in the model. Let $X_t = [\pi_t,\ \pi_{t-1},\ y_t,\ y_{t-1},\ i_{t-1},\ v_t,\ v_{t-1}]'$ be the column vector of the state variables. By substituting out the real exchange rate using Equation (3), the model can be written in terms of the state variables as:

$$\pi_{t+1} = \mu\pi_t + \alpha y_t + \gamma(-\theta(i_t - \pi_t) + v_t + \theta(i_{t-1} - \pi_{t-1}) - v_{t-1}) + \epsilon_{t+1}^{AS} \quad (6)$$

$$y_{t+1} = \lambda_1 y_t + \lambda_2 y_{t-1} - \beta(i_t - \pi_t) + \delta(-\theta(i_t - \pi_t) + v_t) + \epsilon_{t+1}^{IS} \quad (7)$$

$$v_{t+1} = \rho v_t + \epsilon_{t+1}^{e} \quad (8)$$

In matrix form

$$X_{t+1} = AX_t + Bi_t + \epsilon_{t+1}$$

where $$X_t = \begin{bmatrix} \pi_t \\ \pi_{t-1} \\ y_t \\ y_{t-1} \\ i_{t-1} \\ v_t \\ v_{t-1} \end{bmatrix},\ A = \begin{bmatrix} \mu+\gamma\theta & -\gamma\theta & \alpha & 0 & 0 & \gamma & -\gamma \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ \beta+\delta\theta & 0 & \lambda_1 & \lambda_2 & 0 & \delta & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & \rho & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 \end{bmatrix},\ B = \begin{bmatrix} -\gamma\theta \\ 0 \\ -(\beta+\delta\theta) \\ 0 \\ 1 \\ 0 \\ 0 \end{bmatrix} \text{ and } \epsilon_t = \begin{bmatrix} \epsilon_t^{AS} \\ 0 \\ \epsilon_t^{IS} \\ 0 \\ 0 \\ \epsilon_t^{e} \\ 0 \end{bmatrix} \quad (9)$$

It is assumed that the objective of monetary policy is to minimize the weighted average of the variances of inflation and output gap. Specifically, the loss function of the central bank is given by

$$L_t = (1 - \Phi_y)\, Var(\pi_t) + \Phi_y\, Var(y_t) \quad (10)$$

where $0 \le \Phi_y \le 1$ is the weight attached to the variance of y_t.

As Rudebusch and Svensson (1999) show, the optimal instrument rule will be of the form:

$$i_t = f_i X_t \quad (11)$$

and f_i can be derived from solving the stochastic linear regulator problem (Sargent, 1987). One complication is that the interest rate implied by Equation (11) can be negative. To prevent this, we estimate f_i by minimizing the loss function subject to Equations (9) and (10), and a non-negativity condition for the nominal interest rate. Strictly speaking, the resulting feedback rule may not be optimal because an optimal function under the non-negativity condition is non-linear. However, it will be regarded as the optimal monetary policy rule, since our focus is to evaluate the historical interest rate rule of Equation (5)' in the class of linear feedback rules.

The optimal monetary policy rule can be more easily interpreted in the form of Taylor-type rules. To utilize this, recover the real exchange rate using Equation (3) as:

$$e_t = fX_t$$
$$e_{t-1} = f_{-1}X_t$$

where $f = [\theta\ 0\ 0\ 0\ 0\ 1\ 0] - \theta f_i$ and $f_{-1} = [0\ \theta\ 0\ 0\ -\theta\ 0\ 1]$. Then replace v_t and

v_{t-1} with e_t and e_{t-1}, and let $Z_t = [\pi_t\ \pi_{t-1}\ y_t\ y_{t-1}\ i_{t-1}\ e_t\ e_{t-1}]$. This gives

$$Z_t = A_z X_t$$

where A_z is an identity matrix with the last two rows being replaced with f and f_{-1}.

From $X_t = A_z^{-1} Z_t$, the optimal policy rule can be cast as:

$$i_t = f_i A_z^{-1} Z_t$$

or equivalently,

$$i_t = b_1^o \pi_t + b_2^o \pi_{t-1} + b_3^o y_t + b_4^o y_{t-1} + b_5^o i_{t-1} + b_6^o e_t + b_7^o e_{t-1} \quad (12)$$

Note that Equation (12) is of the same form as the unconstrained policy rule in Equation (5).

Ⅳ. The Effectiveness of Monetary Policy

To evaluate the effectiveness of monetary policy, we estimate the model of Equations (1) to (4) under the optimal monetary policy rule in Equation (12). For a better understanding, a set of different objective functions are considered: namely, inflation targeting (IT), equally weighted inflation and output gap targeting (IYT), and output gap targeting (YT). They correspond to the cases of $\Phi_y = 0$, $\Phi_y = 0.5$ and $\Phi_y = 1$, respectively, in Equation (10). Table 3 reports the variances of the variables calculated under the objective functions of IT, IYT, and YT.

All the variances are much smaller than those observed in the actual data. Of particular interest are the variances of inflation and output gap, which constitute the objective functions of monetary policy. The results clearly show that there are gaps between the historical variances of inflation and the output gap, and those implied by the optimal instrument rule. This optimal policy is derived ex-post after observing all data and assuming the private agents do not take into account the optimal policy rule. Consequently, such an ex-post evaluation of the discrepancies between historical data and the one implied by the derived optimal rule may not be quantitatively interpreted as an evidence against the efficiency of the monetary policy rule. While Rudebusch and Svensson (1999) are subject to the same problem, they focus on measuring relative performances of the optimal policy rules under alternative specifications. In our case, we can use the discrepancies as relative metrics for evaluating the historical policy rules as follows. While the variance of output gap is over 7%, it is only 1.69% under the optimal monetary policy rules. For inflation, its variance reduces, but only by less than a half. An additional implication is, hence, that the actual monetary policytended to be relatively more successful in controlling the volatility of

<Table 3> Variances of the Variables

Φ_y	Var(π_t)	Var(y_t)	Var(e_t)	Var(i_t)
IT	2.78	1.69	6.28	9.99
IYT	2.81	1.61	10.08	13.75
YT	2.82	1.62	11.51	14.97
Data	4.27	7.04	66.53	27.41

Note: The top three rows represent the variances implied by the structural model under the optimal monetary policy for inflation targeting (IT), the equally weighted inflation-output gap targeting (IYT) and the output gap targeting (YT). The last row reproduces the actual variances.

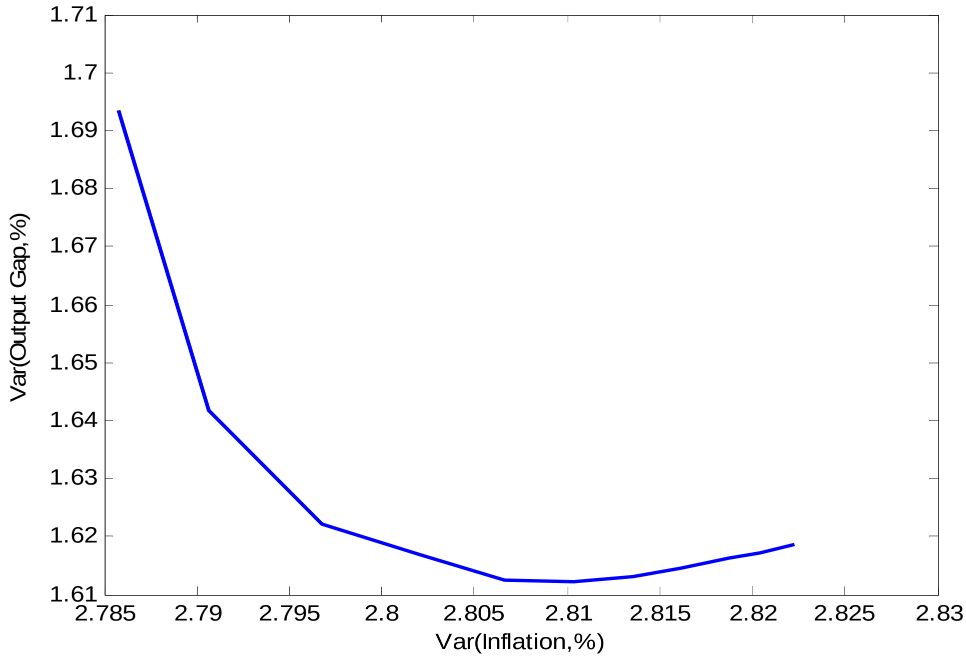
inflation than the volatility of output gap.

Among the objective functions, IT records the smallest variance of inflation and the largest variance of the output gap. As Φ_y goes up, the variance of inflation gets larger, while that of the output gap gets smaller. This would be expected from the tradeoff between the variances of inflation and output. Figure 3 shows, however, that the observed tradeoff is quite small. When there is a regime shift from IT to YT, the variance of inflation increases by 0.04%p and the variance of output gap falls by 0.07%p. The tradeoff between the two gets particularly weaker in the case that Φ_y is over 0.5. For example, IYT and YT produce the variances of inflation and output gap of the almost same magnitude.

Table 4 reports the optimal policy rules in the form of Taylor-type rules. The coefficients on inflation and output gap are unanimously positive, consistent with economic theory. The optimal policy rule in IT calls for most strong reaction to inflation. IYT and YT also command that the interest rate rise more than one for one with inflation, as the coefficients are estimated at 2.75 and 2.42. In these cases, the weights attached to output gap are 2.67 and 2.58, respectively. For comparison, also reported in the table is the estimated Taylor rule by OLS. The coefficients on contemporaneous and lagged inflation are estimated at 0.16 and -0.19, The corresponding features for output gap are -0.01 and 0.22, respectively. All these estimates are quite smaller than those implied by the optimal policy rules. This suggests that the BOK did not actively stabilize inflation and the output gap. A consequence is that the actual variances of inflation and output gap are larger than the variances implied by the optimal monetary policy rules, as Table 3 already showed.

Another important result is concerning the reaction of the BOK to movements in the real exchange rate. From Equations (2)' and (3)', a rise in the real interest rate yielded a real depreciation, which, in turn, caused the output gap to decline. In presence of a real depreciation, hence, the optimal monetary policy rule lowers the interest rate to stabilize inflation and the output gap. The estimation results in Table 4 confirm this, as the coefficients on the real exchange rate are all negative in the range of -0.91 to -2.85. However, the historical Taylor rule has an estimated coefficient of 0.19, indicating that the interest rate has actually risen in response to

[Figure 3] Trade off between the Variance of Inflation and Output Gap



Note: This Figure shows the inflation-output gap variance frontier implied by the structural model under the optimal monetary policy.

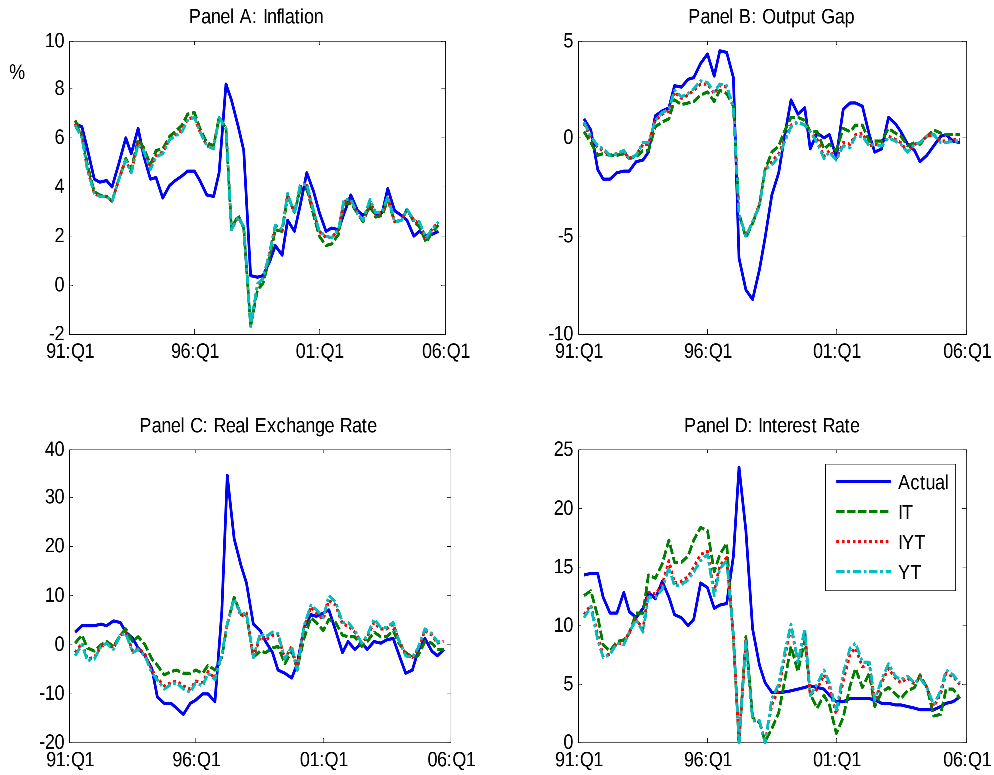
<Table 4> Optimal Monetary Policy Rules

$$i_t = b_1\pi_t + b_2\pi_{t-1} + b_3 y_t + b_4 y_{t-1} + b_5 i_{t-1} + b_6 e_t + b_7 e_{t-1}$$

Φ_y	b_1	b_2	b_3	b_4	b_5	b_6	b_7
IT	5.6590	-1.8874	3.3456	-1.2710	0.3612	-2.8497	0.3681
IYT	2.7510	-1.9029	2.6671	-0.8306	0.6146	-1.1117	0.0545
YT	2.4200	-1.8541	2.5783	-0.8105	0.6467	-0.9068	0.0087
Estimated Taylor Rule	0.1614	-0.1896	-0.0146	0.2182	0.9169	0.1867	-0.1905

Note: The top three rows represent the coefficients in the optimal interest rate rule under inflation targeting (IT), the equally weighted inflation-output gap targeting (IYT) and the output gap targeting (YT). The last row show the coefficient obtained by the ordinary least squares estimation.

[Figure 4] Target versus Actual



Note: This Figure show the actual data (solid lines) with the values implied by the optimal monetary policy under inflation targeting (IT, dashed lines), equally weighted inflation and output targeting (IYT, dotted lines) and the output gap targeting (YT, dash-dotted lines).

the real depreciation. This may well amplify the volatilities of inflation and output gap as well as the volatility of real exchange rates itself.

Figure 4 draws actual and optimal paths of inflation, the output gap, the real exchange rate, and the nominal interest rate. For a few years prior to the financial crisis, the output gap had been expanding, whereas inflation was moderate around 4%. The interest rate, however, remained at lower levels, which would have added momentum to the economy. The real exchange rate was overvalued because the government tries to support a strong won. Large current account deficits were accumulated as a result. During that period, the optimal monetary policy rules continuously signaled that the interest rate must go higher. According to Equations (2)' and (3)', a rise in the interest rate yields a real depreciation which, in turn, causes the output gap to fall. This should act to stabilize the economy with the variables returning to their optimal levels. As shown in the figure, the volatilities of inflation and output gap would have been reduced as well.

Ⅴ. Conclusion

This paper has set out to examine the efficiency of monetary policy in Korea. We construct a small open macroeconomic model that captures key features of the Korean economy. The optimal monetary policy rule is then derived from the model with zero lower bound constraint of the nominal interest rate. The paper considers three different objective functions of monetary policy: namely, inflation targeting, equally weighted inflation and output gap targeting, and output gap targeting. The implied optimal monetary rules are used as a gauge for evaluating the efficiency of the historical monetary policy rule. The main findings can be summarized as follows.

First, the actual monetary policy rule was not very effective in stabilizing inflation and the output gap. The BOK could have achieved much lower variances of inflation and especially the output gap if it had responded strongly against upward pressures in inflation and output gap. Second, while the actual monetary policy was not effective, it was relatively more successful in containing the volatility of inflation than the volatility of output gap. This suggest that the BOK tends to focus more on the stability of inflation in accordance with the premise of inflation targeting. However, the seemingly relative success in stabilizing inflation variation is not supported by the monetary policy rules. Finally, the BOK did not react right to movements in the real exchange rate. This failure is likely to amplify the volatility of inflation and output gap as well as the volatility of real exchange rates itself.

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