Inflation Targeting in a Stable Growth Economy: The Korean Experience

Junggun Oh*

In an economy characterized by stable growth and low inflation, the slope of a non-linear Phillips curve may become flatter. As a result, the degree of sacrifice of employment needed to reduce the inflation rate increases. Therefore, it is necessary to carry out inflation targeting monetary policy more flexibly including a careful reexamination of both the target inflation rate to restore economic growth toward full employment and of the appropriate level of interest rate to achieve the target inflation rate. The costs of reducing inflation as well as the benefits of doing so should be taken into account together in a balanced manner. An optimal target rate of inflation becomes more important in escaping from unnecessary unemployment.

In this regard, the form of the Phillips curve has important implications for monetary policy. In Korea, a non-linear Phillips curve is estimated to be concave. The estimated full employment rate of inflation (FERI) is still within the upper bound of the band of the current target inflation rate and, according to the simulation result, the level of the current rate of interest seems reasonable. Statistically, however, the output gap is only insignificantly influenced by a change in the interest rate mainly because the demand elasticity of interest rate had been almost negligible since the 1997 financial crisis. Therefore, recovering the investment elasticity of interest rates has now emerged as an important issue.

Keywords: Inflation targeting, Nonlinear Phillips curve, Monetary policy, Korea

JEL Classification: E52, E58, E12

* Deputy Director General, Institute for Monetary and Economic Research, The Bank of Korea, Seoul 100-794, Korea, (Tel) +82-2-759-5441, (E-mail) ojunggun@bok.or.kr. Paper prepared for the 13th *Seoul Journal of Economics* International Symposium held at Seoul National University, Seoul, September 23, 2005. The views expressed herein are those of the author and do not necessarily reflect those of the Bank of Korea.

I. Introduction

An inflation targeting regime as a new monetary policy implementation system has been adopted in many countries since the 1990s. Korea also adopted it in 1998 just after the occurring of the 1997 financial crisis. This new trend reflects world-wide high inflation in the 1980s. Experiencing high inflation made us realize the importance and benefits of low inflation.

In particular, it is emphasized that the lowering of inflation expectations enhances efficiency of monetary policy in the sense that as inflation expectations decrease, inflation could be contained with a smaller increase in the interest rate, that is, smaller sacrifice of employment. It is also argued that credibility of monetary policy is crucial to reduce inflation expectations, and that it is necessary to announce a nominal anchor of monetary policy and to keep it to strengthen credibility of monetary policy. An inflation targeting regime as a new monetary policy implementation system has emerged on such backgrounds. A nominal anchor of monetary policy is a target inflation rate.

Since the late 1990s, however, inflation rates have fallen considerably. In some countries, economic growth rates have also declined. In consequence, interest rates have decreased as well. Low growth, low inflation and low interest rates have gone coupled since the late 1990s. These economies, which previously experienced rapid growth, may be termed stably growing economies.

In such an economy, the Phillips curve may become flatter, and, as a result, a degree of sacrifice of employment to reduce an inflation rate could increase. Therefore the form of the Phillips curve has important implications for monetary policy. Accordingly, in recent years, studies on the optimal monetary policy based on the nonlinearity of the Phillips curve have become popular as inflation rates decrease (Akerlof *et al.* 1996; Laxton *et al.* 1999; Nobay and Peel 2000; Dolado *et al.* 2005). They argue that the nonlinearity of the Phillips curve has influenced monetary policy through a Taylor-type monetary policy rule including a term reflecting the nonlinearity.

In these circumstances, the costs of reducing inflation as well as the benefit of doing so should be considered together in a balanced way, in contrast to the high inflation period when the benefits of reducing inflation were more strongly emphasized. In this regard, some authors have tried to search for an optimal point on the trade-off relationship between the inflation rate and the growth rate (an un-unemployment pace) (Akerlof *et al.* 1996; Fuhrer 1997). Others have put forward the concept of the optimal target rate of inflation (Thornton 1996). A number have argued that policy attempts to reduce inflation volatility increase output volatility greatly (Fuhrer 1997; Cecchetti and Ehrmann 1999), which some have stressed the importance of the credibility of monetary policy in an era of price stability since enhanced credibility improves the inflation-unemployment trade-off and thus can reduce inflation with a smaller rise in unemployment (Svensson 2000; Clifton *et al.* 2001). In short, in a stable growth environment, the costs of reducing inflation as well as its benefits should be taken into account together, and then the optimal target rate of inflation becomes more important to escape from unnecessary unemployment.

In the case of a negative output gap, that is, where actual output is less than potential output, the recovery of output should be taken into account in monetary policy implementation as well as maintaining inflation at a stable level. That is to say a flexible inflation targeting regime. In consequence, the monetary authority tends to move its policy emphasis more toward economic growth, and increasing the weight on economic growth calls for lower interest rates. However, in such an economy, interest rates are already low, and, therefore, the scope for lowering them further is likely to be limited. Strikingly, in such a case where the investment elasticity of interest rate is low, the effectiveness of monetary policy might be reduced. A change in the degree of sacrifice of employment needed to reduce the inflation rate and its influence on monetary policy can be more effectively examined with a nonlinear Phillips curve rather than a conventional linear Phillips curve.

The Korean economy experienced a severe structural break during the 1997 financial crisis. On average, GDP growth rate declined substantially from 8.4 percent during the pre-crisis period, from the 1*st* quarter in 1982 to the 2*nd* quarter of 1997, to stand at 4.5 percent during the post-crisis period running from the 4*th* quarter of 2000 to the 2*nd* quarter of 2005. Inflation rates also declined. The core inflation rate fell from 5.0 percent during the pre-crisis period (from the 3*rd* quarter of 1982 to the 4*th* quarter of 1997) to 3.1 percent during the post-crisis period (from the 4*th* quarter of 2000 to the 2*nd* quarter of 2005). As a consequence, nominal interest rates also declined considerably. The call rate declined from 12 percent to 4 percent during the same period. The characteristic phenomenon of simultaneous low growth, low inflation, and low interest rate was observed after the crisis. In recent years, even a negative output gap has opened up (see Appendix Figure 1). Accordingly, to avoid unnecessary unemployment, the costs of reducing inflation as well as its benefits, and then optimal target rate of inflation should be carefully reexamined.

In the following section II, a new Keynesian model with a *nonlinear* Phillips curve will be examined. A new Keynesian model popularly employed in recent years for analysis of inflation targeting (Clarida *et al.* 1999; Blanchard and Gali 2005) will be combined with the nonlinear Phillips curve. In section III, empirical analysis will be carried out to scrutinize how the nonlinear-Phillips curve has changed after the crisis, and how such change in this particular nonlinear Phillips curve has influenced monetary policy. We then search for an optimal level of the target inflation rate to reflect changed economic circumstances. Finally, a summary and some conclusions are set out in section IV.

II. New Keynesian Model with a Nonlinear Phillips Curve

A. Nonlinear Phillips Curve

Generally, an economy that is growing stably at below its potential growth with a low inflation rate, a non-linear Phillips curve may become flatter, than in its high growth period, and, as a result, the degree of sacrifice of employment needed to reduce the inflation rate may increase (see Figure 1).

In this economy, the question of what represents an appropriate level of the target inflation rate to restore economic growth toward a full employment path or, at least, to escape from unnecessary unemployment naturally becomes an important issue. The inflation rate accompanying full employment could be termed, the Full Employment Rate of Inflation (FERI). Here full employment does not necessarily mean that labor supplies are completely employed and thus the unemployment rate is zero. In fact, statistically, full employment is not regarded as zero unemployment.

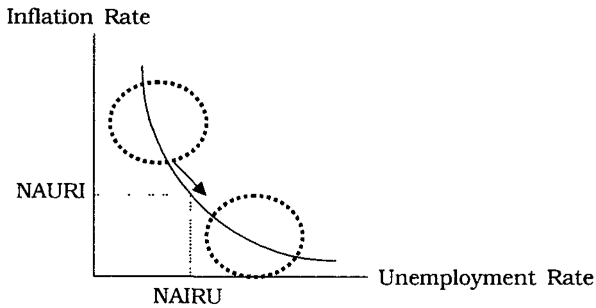


FIGURE 1
PHILLIPS CURVE

In a nonlinear Phillips curve, as the unemployment rate decreases beyond a certain point, the inflation rate begins to increase at an accelerating rate. This point at which unemployment rate is at a minimum without an accelerating increase of the inflation rate may be regarded as full employment. In that sense, the Non-Accelerating Inflation Rate of Unemployment (NAIRU) is this kind of full employment. Conversely, in a nonlinear Phillips curve, as the inflation rate decreases beyond a certain point, the unemployment rate begins to increase at an accelerating rate. This point of minimum inflation rate without an accelerating increase of unemployment rate may be called the Non-Accelerating Unemployment Rate of Inflation (NAURI). FERI is almost the same concept as NAURI. For the U.S.A., NAIRU and NAURI are estimated as 5.9 percent and 3.0 percent respectively (Akerlof *et al.* 1996). For Korea, NAIRU was estimated as 3.2-3.7 percent in 2003 (Shin 2004) and NAURI at 2.9-3.1 percent (Lee 2002).

As NAIRU was often used as a guideline for growth in a high growth, in high inflation economy, FERI (or NAURI) could be a candidate as a guideline of target inflation rate in a stably growing and low inflation economy.

B. New Keynesian Model with a Nonlinear Phillips Curve

It follows from this argument that the monetary authority tends to move its policy weight more toward economic growth in a flexible inflation targeting system, that is, in its policy objective function, λ

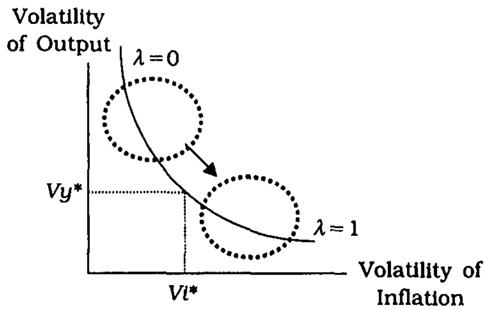


FIGURE 2
POLICY EFFICIENCY FRONTIER

tends to rise.

$$L(\pi_t - \pi^*, y_t) = \frac{1}{2}[(\pi_t - \pi^*)^2 + \lambda y_t^2] \tag{1}$$

where π is the inflation rate, π^* is the target inflation rate, y is the output (in general, GDP) gap rate, and λ is a policy weight between the inflation gap and output gap rate.) As λ rises, volatility of output tends to decrease, while volatility of inflation tends to increase (see Figure 2).

In short, in a stably growing economy, growing, in general, below its potential growth accompanied by a low inflation rate, a rise in the sacrifice ratio and as a result, a change in policy stance of the monetary authority in favor of greater economic growth are inclined to take place. We can see with the recently popular new Keynesian model how much such changes influence monetary policy.

The new Keynesian model is composed of a central bank's quadratic loss function in inflation and output performance, a Phillips curve (or AS schedule), an IS schedule (or AD schedule), and a central bank's policy reaction function derived from the above three functions (Clarida *et al.* 1999; Blanchard and Gali 2005).

In every period, the central bank sets the nominal short-term interest rate, i, aiming at maintaining the inflation gap, $\pi - \pi^*$, and output gap rate, y, close to zero. Assuming a quadratic per-period loss function in inflation and output performance,

$$L(\pi_t-\pi^*, y_t)=\frac{1}{2}[(\pi_t-\pi^*)^2+\lambda y_t^2] \tag{1}$$

and a fixed discount rate, δ, the central bank's objective in period t is to minimize the expected present discounted value of the per-period losses:

$$E_t\sum_{s=0}^{\infty}\delta^s L(\pi_{t+s}-\pi^*, y_{t+s}) \tag{2}$$

subject to the following Phillips curve and IS schedule.

The Phillips curve is as follows:

$$\pi_t=\pi_{t-1}+\alpha f(y_{t-1})+u_{\pi,t} \tag{3}$$

with $f(y_t)=y_t+\phi y_t^2, \quad y_t>-1/2\phi,$ (4)

to reflect the non-linearity of the Phillips curve (Dolado *et al.* 2005).

Therefore the non-linear Phillips curve can be expressed as follows:

$$\pi_t=\pi_{t-1}+\alpha y_{t-1}+\alpha\phi y_{t-1}^2+u_{\pi,t} \tag{5}$$

An output gap rate is closely related with an unemployment rate, u, and therefore the non-linear Phillips curve can be expressed in terms of an unemployment rate as follows:

$$\pi_t=\pi_{t-1}-\alpha u_{t-1}-\alpha\phi u_{t-1}^2+u_{\pi,t} \tag{6}$$

Next, the IS schedule is as follows:

$$y_t=\beta y_{t-1}+\eta x_{t-1}-\xi r_{t-1}+u_{y,t} \tag{7}$$

Where E_t is conditional expectations operator, δ and $\beta\in[0,1)$, and $u_{\pi,t}$ and $u_{y,t}$ are zero-mean normally distributed shocks.

Here, in particular, in Equation (3) of the Phillips curve, an output gap rate enters in a nonlinear way, as defined in Equation (4). Linearity in (4) is recovered when $\phi=0$ and the function is convex (concave) if $\phi>0(\phi<0)$. We assume the function to be increasing (1+

$2\phi y>0$). Equation (7) is an IS schedule where the output gap rate exhibits sluggish adjustment, and depends on the real interest rate,

$$r_t = i_t - E_t \pi_{t+1} \tag{8}$$

and on a predetermined/exogenous variables, x_t, for instance, a foreign interest rate or an exchange rate reflecting the openness of the economy. The real interest rate affects output with a one-period lag and therefore affects inflation with a two-period lag. These time lags reflect the transmission mechanism of monetary policy where monetary policy leads to a change in output in the short run while a change in inflation, due to a change in aggregate demand, follows later.

Totally differentiating (2) with respect to i, subject to (5) and (7), yields the following Taylor rule:

$$i_t = c_1 E_{t-1}(\pi_{t+1} - \pi^*) + c_2 E_{t-1} y_t + c_3 E_{t-1} x_t + c_4 E_{t-1}\{(\pi_{t+1} - \pi^*) y_t\} \tag{9}$$

where $c_1 = 1 + \alpha/\lambda\xi\beta$, $c_2 = (1+\delta\beta^2)/\delta\xi\beta$, $c_3 = \eta/\xi$, $c_4 = 2\phi\alpha/\lambda\xi\beta$.

Replacing the expectations by realized values in Equation (9) yields the following central bank's policy reaction function to be used for estimation:

$$i_t = cnst + c_1(\pi_{t+k} - \pi^*) + c_2 y_t + c_3 x_t + c_4(\pi_{t+k} - \pi^*) y_t + \rho_1 i_{t-1} + v_t \tag{10}$$

where k is positive, taking into account the time lags of monetary policy transmission and the central bank's pre-emptive policy implementation, and a lagged dependent variable, i_{t-1} is included to reflect interest rate smoothing.

An error term is defined as follows:

$$v_t = -[c_1\{(\pi_{t+k} - \pi^*) - E_{t-1}(\pi_{t+k} - \pi^*)\} + c_2(y_t - E_{t-1} y_k) + c_3(x_t - E_{t-1} x_t)$$
$$+ c_4(\pi_{t+k} - \pi^*) y_t - E_{t-1}(\pi_{t+k} - \pi^*) y_t]$$

where the term in brackets is a linear combination of forecast errors and therefore orthogonal to any variable in the information set at $t-1$.

The policy reaction function, Equation (10) is slightly changed, following Clarida *et al.* (2000) and Apergis *et al.* (2005), to the following forward-looking rule, Equation (11) for estimation:

$$i_t = cnst + c_1(\pi_{t+k} - \pi^*) + c_2 y_{t+l} + c_3 x_t + c_4(\pi_{t+k} - \pi^*) y_{t+l} + \rho_1 i_{t-1} + v_t \quad (11)$$

where l is positive taking into account the lag effect on output of monetary policy and the central bank's pre-emptive policy implementation.

In the Equations (9), (10), and (11), an interaction term of the inflation gap and the output gap rate represents the non-linearity of the Phillips curve. If the Phillips curve is convex ($\phi > 0$), the future inflation pressure caused by a higher output gap will turn out larger than in the linear case, and therefore, the central bank will react more strongly to a positive inflation gap than to a negative one, and, as a result, the increase in the interest rate will be larger since $c_4 > 0$. On the other hand, if the Phillips curve is concave ($\phi < 0$), the future inflation pressure caused by a higher output gap will turn out smaller than in the linear case, and therefore, the central bank will react more weakly to a positive inflation gap than to a negative one, and, as a result, an increase in the interest rate will be smaller since $c_4 < 0$.

As the economic growth rate decrease, and, therefore, the central bank puts its policy weight more on economic growth in a flexible inflation targeting system, λ in its policy objective function rises. On the policy efficiency frontier, if the volatility of output decreases beyond a certain point Vy^*, then, as λ increases, volatility of inflation increases at an accelerating rate, while if the volatility of inflation decreases beyond a certain point Vi^*, then, as λ decreases, the volatility of output increases at an accelerating rate. For the U.S.A., estimated Vi^* is 2 percent (Fuhrer 1997). That means that balanced responses to inflation and output are important in monetary policy.

On the other hand, if λ rises, the values of coefficient c_1 and c_4 decrease. A decrease in the value of coefficient c_1 leads to a lower interest rate.

However, in a stably or slowly growing economy, interest rates are already low, and, therefore, the scope for lowering interest rates tends to be limited. Such a situation could reduce the effectiveness of monetary policy. In particular, where the investment elasticity of interest rates is low, in such a case, the effectiveness of monetary policy could be severely damaged.

III. Empirical Analysis

A. Data

The Korean economy experienced a severe structural break during the 1997 financial crisis. In addition, in 1998 just after the crisis, an inflation targeting regime was adopted (Oh 1999a, 2004, and 2005). This means that there was a considerable policy break in 1998 as well. Therefore, we use two sample periods, that is, a pre-crisis period from the 1*st* quarter of 1982 to the 2*nd* quarter of 1997, and a post-crisis period from the 3*rd* quarter of 1998 to the 1*st* quarter of 2005. The period from the 3*rd* quarter of 1997 to the 2*nd* quarter of 1998 was excluded so as to remove the direct effects of the crisis and the technical rebound just after the crisis.

Quarterly data of call rate, core price index, real GDP, nominal exchange rate, the import price index in terms of the U.S. dollar, the nominal wage rate index and the unemployment rate are used. Among them, real GDP, core price index, nominal exchange rate, import price index, nominal wage rate index and unemployment rate are all seasonally adjusted and then transformed into natural logarithms. The GDP gap rates are calculated from differences of log seasonally adjusted real GDP series and its log HP filtered series. The core inflation rate is calculated from the log difference of the seasonally adjusted core price index.

Unit root tests are carried out on all data. The call rate, core inflation rate, GDP gap rate, log nominal wage rate index, and log unemployment rate have no unit root, while the log nominal exchange rate and log import price index show $I(1)$ series (see unit root test results in Appendix Table 2), and, therefore, for those two series, first difference series are used for estimation.

B. Nonlinear Phillips Curve

As preliminary studies, reviews on existing literatures and regression on a simple linear Phillips curve are carried out. First, according to a literature review of empirical studies on the Korean economy, estimated NAIRU and NAURI were respectively 3.2-3.7 percent in 2003 (Shin 2004) and 2.9-3.1 percent (Lee 2002). Comparing it with recent actual data on the unemployment rate and core inflation rate, the actual unemployment rate was 3.9 percent on average from

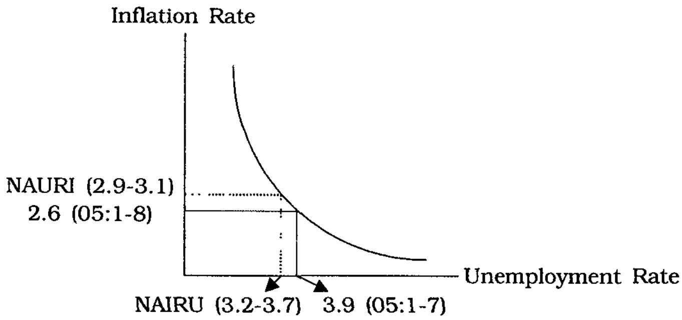


FIGURE 3
PHILLIPS CURVE

January to July 2005, slightly higher than estimated NAIRU, and the actual core inflation rate was 2.6 percent on average from January to August 2005, lower than estimated NAURI. The recent actual core inflation rate is approaching to the lower bound of target range of core inflation, set at 2.5-3.5 percent.

Next, simple linear Phillips curves with core inflation rate (*lncore*) and log unemployment rate (*lnun*), $lncore = c_0 + c_1 lnun$, are estimated with an ordinary least squares method for pre-crisis period and post-crisis period respectively to see whether the Phillips curve became flatter in the stably growing post-crisis period than in the highly growing pre-crisis. An estimated coefficient c_1 for the pre-crisis period is -5.746, while that for the post-crisis period is -3.736. Accordingly, the Phillips curve seems to have become flatter in the post-crisis period than in the pre-crisis period and thus a degree of sacrifice of employment needed to reduce the inflation rate is likely to have increased (see Appendix Figure 2).

In addition, in order to examine whether the Phillips curve has become flatter in the post-crisis period than in the pre-crisis period, the nonlinear Phillips curve, Equation (5) and (6), are both estimated for the post-crisis period and for the pre-crisis period. Estimation results are as set out below:

For the post-crisis period, estimated coefficients are mostly statistically significant. In particular, ϕ is negative, that is, the Phillips curve is concave ($\phi<0$). Accordingly, the future inflation

TABLE 1
ESTIMATION RESULTS OF PHILLIPS CURVE

<Post-Crisis Period>

$$lncore = \underset{(4.2411)}{1.8493} + \underset{(4.6049)}{0.5423}{*}lncore(t-1) + \underset{(3.5093)}{0.3694}{*}lngdpgap(t-1) - \underset{(-4.8077)}{0.3425}{*}lngdpgap(t-1)^2$$

$R^2 = 0.8776$ $\quad D.W. = 1.2302$

$$lncore = \underset{(1.2173)}{24.2897} + \underset{(4.1468)}{0.6026}{*}lncore(t-1) - \underset{(-1.8885)}{74.4984}{*}lnun(t-1) + \underset{(1.2193)}{59.8357}{*}lnun(t-1)^2$$

$R^2 = 0.5294$ $\quad D.W. = 2.1787$

<Pre-Crisis Period>

$$lncore = \underset{(1.2138)}{0.3897} + \underset{(17.2539)}{0.9363}{*}lncore(t-1) - \underset{(-0.9989)}{0.0873}{*}lngdpgap(t-1) - \underset{(-0.8908)}{0.0519}{*}lngdpgap(t-1)^2$$

$R^2 = 0.8618$ $\quad D.W. = 1.3124$

$$lncore = \underset{(-1.2651)}{-3.1321} + \underset{(12.7152)}{0.8386}{*}lncore(t-1) + \underset{(1.7936)}{8.4859}{*}lnun(t-1) - \underset{(-1.9810)}{4.3186}{*}lnun(t-1)^2$$

$R^2 = 0.8725$ $\quad D.W. = 1.3580$

Note: Numbers in parentheses are t-statistics

pressure caused by a higher output gap seems smaller than in the linear case. On the other hand, for the pre-crisis period, the coefficients estimated with the unemployment rate are statistically significant, while coefficients estimated with the GDP gap rate are statistically insignificant. As for estimation with the un-unemployment rate, however, ϕ is positive, that is, the Phillips curve is convex ($\phi > 0$). Accordingly, the future inflation pressure caused by a higher output gap seems to have been larger than in the linear case.

C. New Keynesian Model with a Nonlinear Phillips Curve

In order to examine how a decrease in the growth rate and a resultant change in the Phillips curve have influenced monetary policy, the above new Keynesian Model composed of the central bank's loss function (Equation (1)), a Phillips curve (Equation (5)), an IS schedule (Equation (7)), and the central bank's policy reaction function (Equation (11)) derived from the above three functions are simultaneously estimated with a seemingly unrelated estimation method for the post-crisis period.

In the Phillips curve, the variables of the exchange rate, import prices and wage rates are further added as cost factors, and in the IS schedule, an exchange rate variable is added in view of the high dependence on exports of the Korean economy. In the policy reaction function, taking into account the time lags of monetary policy transmission and the central bank's pre-emptive policy implementation, k and l are respectively chosen to be 2 and 1 (Oh 1999b, 2000). Here a variable of the exchange rate is also included. An exchange rate variable is included in many other studies on open economy inflation targeting models (Ball 1999; Svensson 2000; Clarida 2001; Taylor 2001; Mohanty and Klau 2004). In this paper, an exchange rate variable is included in all three equations in view of the high external dependence of the Korean economy. Estimation results are as in Appendix Table 1. The results of ex-post simulation of the model are attached in Appendix Figure 3.

As for the Phillips curve, most coefficients are statistically significant and the signs of the coefficients are the same as expected. In particular, as in the above estimation of the single Phillips curve, ϕ is negative, that is, the Phillips curve is concave ($\phi<0$).

As for the policy reaction function, all the coefficients are statistically significant and the signs of the coefficients are the same as expected except for the coefficient of an exchange rate. The lack of significance of the exchange rate seems due to an increase in the capacity for the implementation of monetary policy independently of exchange rates movements following the adoption of flexible exchange rate regime after the 1997 crisis.

In particular, the coefficient of the interaction term of the inflation gap and output gap rate representing the non-linearity of the Phillips curve is statistically significantly negative since ϕ in the Phillips curve is negative. In this case, the central bank tends to react more strongly to a negative inflation gap than to a positive one. Therefore, if the inflation gap is negative, in general, the output gap is also negative, and the interaction term itself of the inflation gap and the output gap is positive. Here the coefficient of the interaction term is now negative, and accordingly, a negative inflation gap will lead to a greater decrease in the interest rate of the central bank.

The long-run Taylor rule derived from the estimated policy reaction function is as follows:

$$\begin{aligned} int = {} & 3.336 + 1.3814*(lncore(t+2) - coretarget) + 0.7039*lngdpgap(t+1) \\ & - 0.1309*dlnex - 0.4759*((lncore(t+2) - coretarget)*lngdpgap(t+1)) \end{aligned}$$

Here a constant term 3.336 represents the long-run equilibrium interest rate that is the interest rate when inflation gap, output gap and the rate of change in the exchange rate are all zero. The coefficient of the inflation gap is larger than 1, and thus when the inflation gap is expected to be positive, the nominal interest rate increases more than the expected inflation gap and, as a result, the real interest rate remains positive.

As for the IS schedule, the coefficient of the exchange rate is statistically significant and its sign is positive as expected, while the coefficient of the real interest rate is statistically insignificant and its sign is also mixed. The lack of significance of the coefficient of the real interest rate seems to reflect the current low investment and consumption elasticity of interest rate.

FERI is estimated for the post-crisis period using the above estimated Phillips curve. In this paper, the inflation rate with a zero GDP gap rate is assumed as FERI. Estimated FERI is slightly higher than the mid-point of the target core inflation rate (3 percent), but still within the upper bound of the target inflation range (2.5-3.5 percent) for recent years (see Appendix Figure 4). This result is almost the same as in Lee (2002).

Once FERI is estimated, it is crucial to decide an appropriate or optimal level of interest rate to achieve the target inflation rate. An appropriate interest rate level is estimated with the estimated new Keynesian model and FERI. The estimated appropriate level of interest rate seems to be slightly lower than the current rate of interest, but this difference is not great either (see Appendix Figure 5).

In order to examine how much a change in target inflation rate influences the call rate, output gap and the inflation rate, dynamic simulation of the above estimated new Keynesian model was carried out. According to the results of the dynamic simulation, as the core inflation target increases step by step, the appropriate level of interest rates becomes slightly lower. Even in such a case, however, the output gap is scarcely influenced mainly because the demand elasticity of interest rates is almost negligible in the post-crisis period.

According to the estimation results of the above new Keynesian model, only the coefficient of the real interest rate in the IS schedule is statistically insignificant and its sign is also mixed. This seems to reflect the recent situations of the Korean economy where there has been little investment in spite of a sustained decline in interest rates. Due to the absence of change in aggregate demand, the inflation rate is not affected either. Therefore, the above dynamic simulation shows that, at the moment, the most important issue in the Korean economy seems to recover demand elasticity, in particular, the investment elasticity of interest rate. The level of the interest rate itself seems sufficiently low according to the simulation results.

IV. Summary and Conclusions

In a stably growing economy, growing below its potential growth, a low growth rate tends to be accompanied by a low inflation rate and a low interest rate. In such an economy, compared with its high growth period, the Phillips curve may become flatter and, as a result, the degree of sacrifice of employment needed to bring down the inflation rate increases. As a consequence, the monetary authority tends to move the weight of its policy more toward economic growth in a flexible inflation targeting system, and the increasing weight on economic growth entails lower interest rate. However, in such an economy, interest rates are already low, and, therefore, the scope for lowering them further is likely to be limited. Such a situation may reduce the effectiveness of monetary policy. In particular, in such a case where demand elasticity of interest rate is low, the effectiveness of monetary policy could be severely damaged.

Accordingly, first of all, the question of how best to enhance the effectiveness of monetary policy even with a small change in the interest rate becomes an important issue. In this regard, we should identify which step does not work well in the monetary policy transmission mechanism running from short-term interest rates to medium and long-term interest rates, and from medium and long-term interest rates to final demand. And then demand elasticity, in particular, the investment elasticity of interest rates in such an economy should be raised.

Secondly, the inflation rate is low and the growth rate is below its potential. Accordingly, the level of the target inflation rate should be carefully reexamined to restore economic growth on a path toward full employment. The inflation rate accompanying full employment could be named the Full Employment Rate of Inflation (FERI) or the Non-Accelerating Unemployment Rate of Inflation (NAURI). As the Non-Accelerating Inflation Rate of Unemployment (NAIRU) was often used as a guideline for growth in a high growth and high inflation economy, FERI (or NAURI) could be one of the guidelines of the target inflation rate in a stably growing and low inflation economy. It is noteworthy that the lower bound as well as the upper bound of the inflation target range in a flexible inflation targeting system is regarded as important to escape from unnecessarily low growth or even deflation, and the resultant high unemployment.

Thirdly, it is obviously crucial to choose the appropriate (or optimal) level of interest rate to achieve the target inflation rate. In this regard, a step by step approach with careful feedback rather than a once-and-for-all approach to achieve full employment as well as non-accelerating inflation could be recommended.

Having enjoyed high growth before the 1997 financial crisis, the Korean economy is currently experiencing the new phenomenon of unprecedented long-term stable (or low compared with the pre-crisis period) growth after a severe structural break during the crisis. In this regard, it is even argued that the Korean economy has changed structurally. However, we are now observing the typical phenomena of a stable (or low) growth economy, including simultaneous low growth, low inflation, low interest rates and high asset prices in Korea.

Consequently, studies on the relationship between inflation and unemployment with a nonlinear Phillips curve show that the degree of sacrifice of employment needed to reduce the inflation rate seems to be rising. Therefore, it seems desirable to conduct inflation targeting monetary policy more flexibly including carefully reexamining the target inflation rate needed to restore economic growth to a full employment path and the appropriate level of interest rates to achieve the target inflation rate when the growth rates is expected to remain below the potential growth rate. However, according to the results of empirical studies based on a new Keynesian model, the effectiveness of even a flexible monetary policy would be limited mainly because of the extremely low demand elasticity of interest rates after the crisis. Therefore, at the moment, it is crucial, first of all, to enhance the effectiveness of monetary policy by raising the investment elasticity of interest rates.

This paper, however, has some limitations. In particular, it does not include the asset market. Actually, the issue of how to incorporate asset price into monetary policy analysis and implementation remains controversial. Some argue that asset prices should be taken directly into account in the monetary policy, while others advocate that it be considered only through the price channel which asset prices influence. The conventional new Keynesian model does not include asset prices. This question must remain as a topic for further research.

(Received 14 September 2005; Revised 17 November 2005)

Appendix

Appendix Table 1

Estimation Results of New Keynesian Model

Policy Reaction Function

$$int = \underset{(2.5587)}{0.6069} + \underset{(5.3735)}{0.2527}*(lncore(t+2) - coretarget) + \underset{(3.3306)}{0.1280}*lngdpgap(t+1) - \underset{(-0.0165)}{0.0239}*dlnex$$

$$- \underset{(-1.8403)}{0.0870}*((lncore(t+2) - coretarget)*lngdpgap(t+1)) + \underset{(16.5749)}{0.8171}*int(t-1)$$

$R^2 = 0.9269$ $D.W. = 1.9335$

Phillips Curve

$$lncore = \underset{(-1.0042)}{-4.8283} + \underset{(4.1836)}{0.4700}*lncore(t-1) + \underset{(2.7785)}{0.3718}*lngdpgap(t-1) - \underset{(-4.1490)}{0.3296}*lngdpgap(t-1)^2$$

$$+ \underset{(3.4357)}{9.3403}*dlnex + \underset{(1.9372)}{5.1100}*dlnimp(t-3) + \underset{(1.3760)}{1.4428}*lnwage(t-3)$$

$R^2 = 0.7804$ $D.W. = 2.4833$

IS Curve

$$lngdpgap = \underset{(0.1054)}{0.0312} + \underset{(2.6036)}{0.5043}*lngdpgap(t-1) - \underset{(-0.6718)}{0.2287}*(int(t-4) - lncore(t-3))$$

$$+ \underset{(0.9972)}{0.2587}*(int(t-5) - lncore(t-4)) + \underset{(1.9812)}{12.0000}*dlnex(t-4)$$

$R^2 = 0.4345$ $D.W. = 1.7493$

Notes: 1) Numbers in parentheses are t-statistics

2) Notations

int: nominal call rate

lncore: core inflation rate ((ln(core price index) − ln(core price index(−4))*100) (%)

coretarget: target core inflation rate (%)

lngdpgap: gdpgap rate ((ln(gdp) − ln(HP filtered gdp)*100) (%)

dlnex: lnex − lnex(−1)

lnex: ln(nominal exchange rate)

dlnimp: lnimp − lnimp(−1)

lnimp: ln(import price index, dollar term)

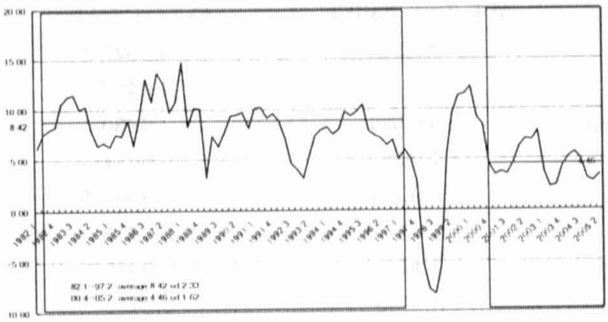
lnwage: ln(wage index)

Appendix Table 2
Unit Root Test Results

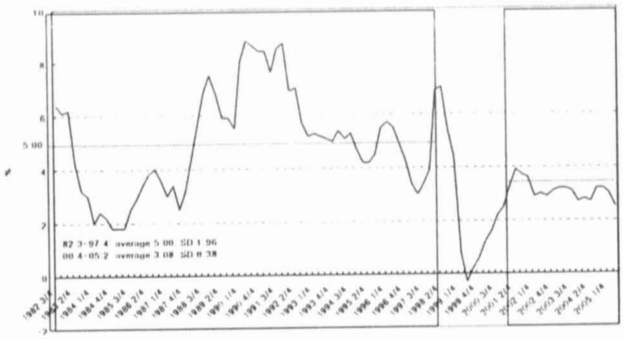
Variables	ADF Test Statistic	Critical Value	
Int	−3.7246	−3.6027**	*I*(0)
Lncore	−2.7856	−2.6457*	*I*(0)
Lngdpgap	−3.0786	−2.9850**	*I*(0)
Lnex	−1.5653	−3.6027	*I*(1)
Dlnex	−3.0056	−2.9907**	*I*(0)
Lnimp	−1.6274	−3.6618	*I*(1)
Dlnimp	−2.1455	−1.9559**	*I*(0)
Lnwage	−3.3772	−3.2418*	*I*(0)
Lnun	−4.5704	−4.3738***	*I*(0)

Note: *, **, and *** indicate significance at the 10, 5, and 1 percent level, respectively.

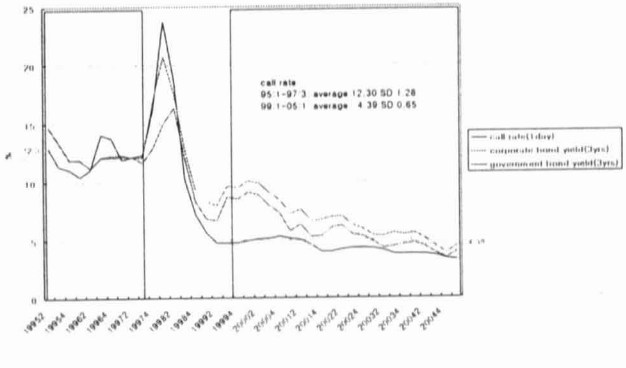
GDP Growth Rate



Core Inflation Rate



Interest Rates

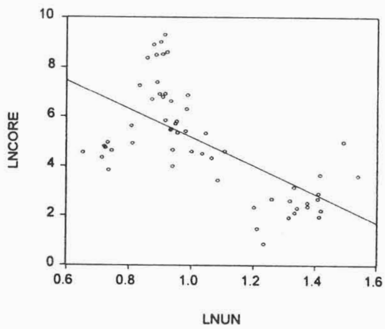


Appendix Figure 1

Growth, Inflation, and Interest Rates

Pre-Crisis Phillips Curve

LNCORE *VS.* LNUN



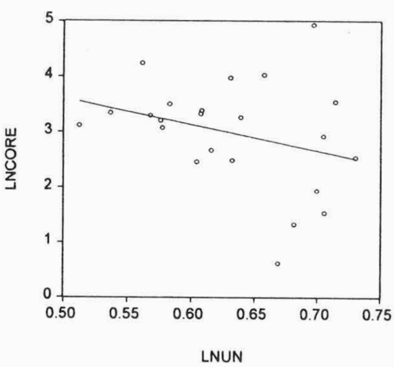
$lncore = 10.906 - 5.746 * lnun$

$R^2 = 0.403$ $D.W. = 0.270$

1982Q1-1997Q2

Post-Crisis Phillips Curve

LNCORE *VS.* LNUN



$lncore = 8.598 - 3.736 * lnun$

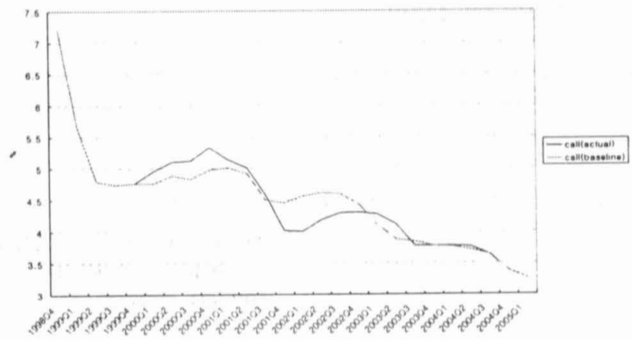
$R^2 = 0.358$ $D.W. = 0.686$

1998Q3-2005Q1

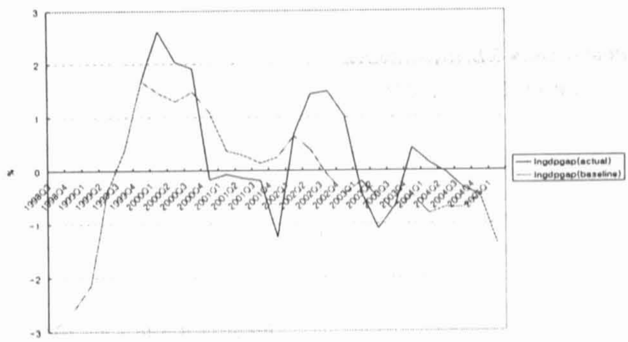
APPENDIX FIGURE 2

PHILLIPS CURVE

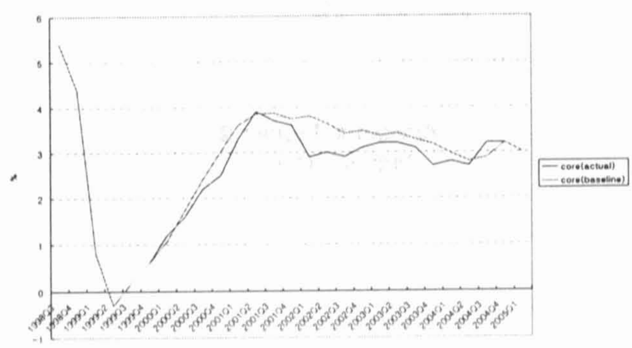
Call Rate



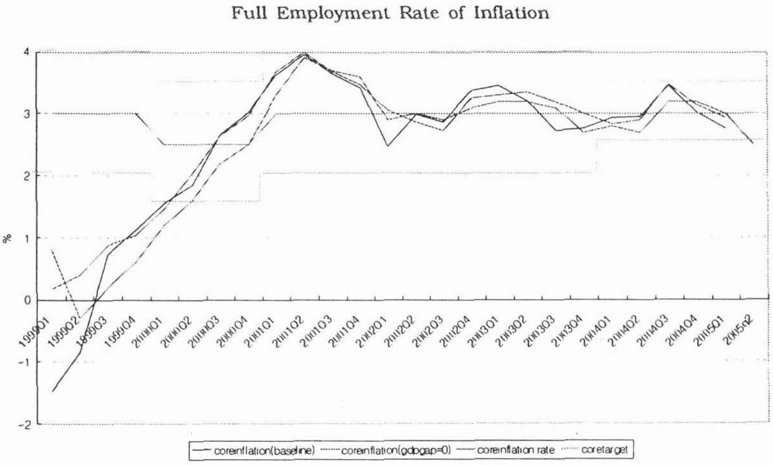
GDP Gap Rate



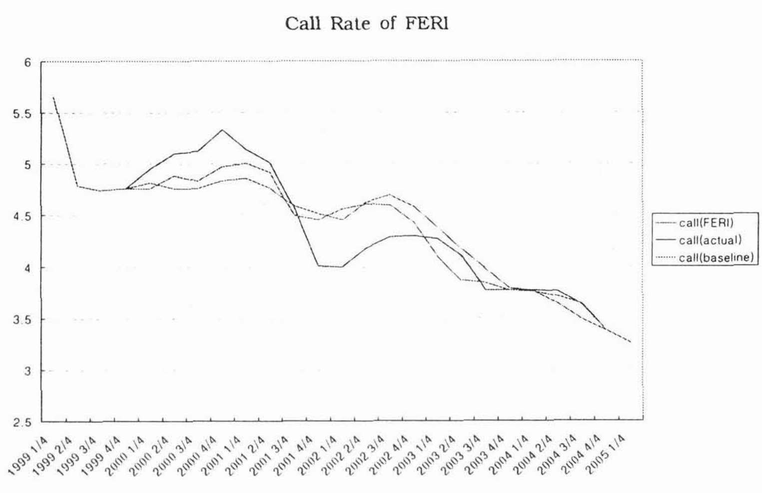
Core Inflation Rate



APPENDIX FIGURE 3
EX-POST SIMULATION RESULTS

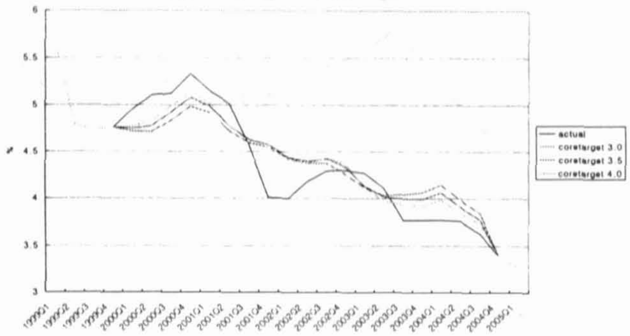


APPENDIX FIGURE 4
FULL EMPLOYMENT RATE OF INFLATION

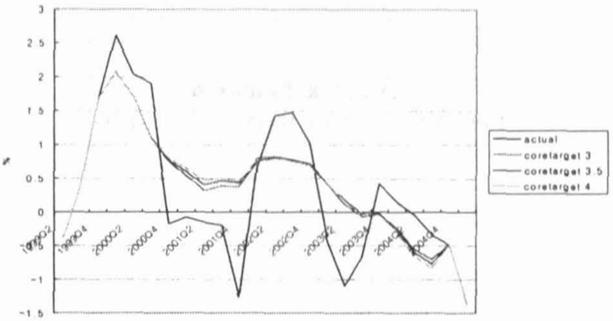


APPENDIX FIGURE 5
CALL RATE OF FULL EMPLOYMENT RATE OF INFLATION

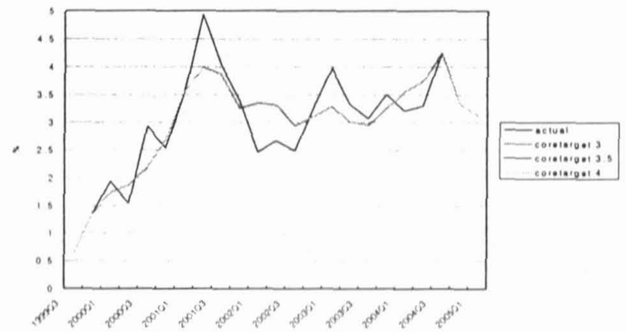
Call Rate by Core Inflation Target after 2003



GDP Gap Rate by Core Inflation Target after 2003



Core Inflation Rate by Core Inflation Target after 2003



APPENDIX FIGURE 6

SIMULATION RESULTS BY CORE INFLATION TARGETS

References

Akerlof, George A., William T. Dickens, George L. Perry, Robert J. Gordon, and N. Gregory Mankiw. "The Macroeconomics of Low Inflation." *Brookings Papers on Economic Activity* (No. 1 1996): 1-76.

Apergis, Nicholas, Stephen M. Millers, Alexandros Panethimitakis, and Athanasios Vamvakidis. Inflation Targeting and Output Growth: Empirical Evidence for the European Union. IMF Working Paper, WP/05/89, May 2005.

Ball, Laurence. "Policy Rules for Open Economies." In John B. Taylor (ed.), *Monetary Policy Rules*. Chicago, Illinois: University of Chicago Press, pp. 127-44, 1999.

Blanchard, Olivier, and Jordi Garli. Real Wage Rigidities and the New Keynesian Model. Jun. 15, 2005.

Cecchetti, Stephen G., and Michael Ehrmann. Does Inflation Targeting Increase Output Volatility? An International Comparison of Policymakers' Preferences and Outcomes. NBER Working Paper No. 7426, Dec., 1999.

Clarida, Richard. "The Empirics of Monetary Policy Rules in Open Economies." *International Journal of Finance and Economics* 6 (October 2001): 315-23.

Clarida, Richard, Jordi Gali, and Mark Gertler. "The Science of Monetary Policy: A New Keynesian Perspective." *Journal of Economic Literature* 37 (December 1999): 1661-707.

________. "Monetary Policy Rules and Macroeconomic Stability: Evidence and Some Theory." *The Quarterly Journal of Economics* 115 (February 2000): 147-80.

Clifton, Eric V., Hyginus Leon, and Chorng-Huey Wong. Inflation Targeting and the Unemployment-Inflation Trade-off. IMF Working Paper WP/01/166, October 2001.

Dolado, Juan J., Ramon Maria-Dolores, and Manuel Naveira. "Are Monetary-policy Reaction Functions Asymmetric?: The Role of Nonlinearity in the Phillips Curve." *European Economic Review* 49 (No. 2 2005): 485-503.

Fuhrer, Jeffrey C. "Inflation/Output Variance Trade-Offs and Optimal Monetary Policy." *Journal of Money, Credit and Banking* 29 (No. 2 1997): 214-34.

Hagen, Jürgen von, and Boris Hofmann. Monetary Policy

Orientation in Times of Low Inflation. Prepared for the Conference on Monetary Policy under Low Inflation, *Federal Reserve Bank of Cleveland*, Nov. 21-23, 2003.

Laxton, Douglas, David Rose, and Demosthenes Tambakis. "The U.S. Phillips Curve: The Case for Asymmetry." *Journal of Economic Dynamics and Control* 23 (No. 8 1999): 1459-85.

Lee, Myungwhal. An Optimal Rate of Target Inflation. Conference Proceedings on Inflation Targeting, The Bank of Korea, October 2002 (in Korean).

Mohanty, M. S., and Marc Klau. Monetary Policy Rules in Emerging Market Economies: Issues and Evidence. BIS Working Paper 149, March, 2004.

Nobay, A. R., and D. A. Peel. "Optimal Monetary Policy with a Nonlinear Philips Curve." *Economics Letters* 67 (No. 2 2000): 159-64.

Oh, Junggun. "How Useful Is an Underlying Inflation Rate for Inflation Targeting?" *Economic Papers* 2 (No. 2 1999a): 29-63.

_________. "Inflation Targeting, Monetary Transmission Mechanism and Policy Rules in Korea." *Economic Papers* 2 (No. 1 1999b): 102-46.

_________. "Inflation Targeting: A New Monetary Policy Framework in Korea." In *Practical Experiences in Inflation Targeting*, The Bank of Thailand, Bangkok, October, 2000.

_________. "Monetary and Exchange Rate Policies." In Charles Harvie, Hyun-Hoon Lee, and Junggun Oh (eds.), *The Korean Economy: Post-Crisis Policies, Issues and Prospects*. Cheltenham, UK: Edward Elgar, 2004.

_________. "Korea's Post-Crisis Monetary Policy Reforms." (with D. Park), *Review of Pacific Basin Financial Markets and Policies* 8 (No. 1 2005): 265-84.

Shin, Sukha. "Korea's Natural Rate of Unemployment: Estimates and Assessment." *KDI Journal of Economic Policy* 26 (No. 2 2004) (in Korean).

Svensson, Lars E. O. How Should Monetary Policy Be Conducted in an Era of Price Stability? NBER Working Paper 7516, Feb., 2000.

_________. "Open Economy Inflation Targeting." *Journal of International Economics* 50 (No. 1 2000): 155-83.

Taylor, John. "The Role of the Exchange Rate in Monetary Policy Rules." *AER Papers and Proceedings* 91 (No. 2 2001): 263-7.

Thornton, Daniel L. The Costs and Benefits of Price Stability: An Assessment of Howitt's Rule. *Federal Reserve Bank of St. Louis*, Mar/Apr., 1996.