Commentary: How Should Monetary Policy Respond to Shocks While Maintaining Long-Run Price Stability? —Conceptual Issues

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Having admired John Taylor's work for about two decades, it is a great pleasure for me to comment upon his paper, especially at this distinguished conference. Being a discussant of his paper is both easy and difficult, though. It is easy to be inspired, but it is very difficult to find something to seriously disagree with.

I find John Taylor's review of the mistakes of the past very inspiring, but I am not willing to write off time-consistency problems as easily as he does. In some European countries, strong labor movements seem to have imposed unrealistically high employment goals on fiscal and monetary policy. These movements seem to have done their best to block any reform and deregulation of labor markets and wage setting, which might lower the natural rate of unemployment, and have instead preferred to assign responsibility for lowering unemployment to fiscal and monetary policy, even though these cannot deliver. John Taylor believes that time-consistency problems can easily be fixed with legislation or other social arrangements. As we all know, there is a very strong case, both theoretically and empirically, for a monetary policy arrangement with a legislated price stability mandate, operational (instrument-) independence, and accountability for the central bank. (See Fischer, 1994.) In practice, though, the politics of such reforms are far from easy. Only recently have a number of countries undertaken such reforms, but reforms are still blocked in some countries, often by labor movements (my own country being a prime example). This is ironic, since labor governments should have more to gain from central bank reform, because they most likely have a larger credibility problem to start with.

Let me get to John Taylor's recommendations for how monetary policy should be conducted to maintain price stability. The points I would like to discuss are (1) inflation targeting implies inflation *forecast* targeting, (2) target rules vs. instrument rules, and (3) price level targeting vs. inflation targeting.

Inflation targeting implies inflation forecast targeting

I completely agree with John Taylor that having an explicit inflation target is the best way to maintain price stability, price stability here meaning low and stable inflation. (I will get to the issue of price *level* targeting later in this commentary.) I will extend on some implications that follow from explicit inflation targeting.

A serious problem in inflation targeting is the imperfect control of inflation due to lags, supply and demand shocks, and model uncertainty. As I have argued elsewhere (Svensson, 1996a), I believe there is a very good solution to this problem, namely to consider the inflation forecast for the control lag as an explicit intermediate target.[1] In his paper at this symposium, Charles Freedman also emphasizes that the inflation forecast should be thought of as an intermediate target for countries with explicit inflation targets. From this general insight follows some very explicit and useful results.

A simple model

Let me start from the stylized fact that both inflation and aggregate demand react with a lag to changes in the central bank's instrument, and that the lag for inflation is longer than for aggregate demand. This can be captured by two equations. The first describes a so-called accelerationist Phillips curve, where the change in inflation depends on output with a lag of one year,

(1) $$\pi_{t+1} = \pi_t + \alpha y_t + \varepsilon_{t+1}.$$

Here π_t is inflation between year t-1 and year t, y_t is (the) output (gap), ε_t is a serially uncorrelated (negative) supply shock with zero mean, and α is a positive constant. The natural output level (consistent with constant inflation) is normalized to zero.

The second equation describes an aggregate demand/IS curve, where output depends on previous output and the real interest rate with a one-year lag,

(2) $$y_{t+1} = \beta_1 y_t - \beta_2(i_t - \pi_t) + \eta_{t+1}.$$

Here the nominal interest rate i_t is the central bank's instrument (for instance, the federal funds rate in the United States, a repo rate in several other countries), η_t is a serially uncorrelated demand shock with zero mean, and β_1 and β_2 are positive constants. If current inflation is taken as a proxy for expected inflation, $i_t - \pi_t$ is a proxy for the real interest rate. The model with these two equations is similar to that used by Taylor (1994), with the addition of an explicit one-year lag in the aggregate demand equation. (The average real interest rate is normalized to zero.)

Thus, an increase in the federal funds rate will lead to a fall in output in one year, and a fall in inflation in two years,

(3) $$i_t\uparrow \Rightarrow y_{t+1}\downarrow \Rightarrow \pi_{t+2}\downarrow.$$

Due to the control lags and the demand and supply shocks that may occur during these lags, control of inflation and output will be imperfect. Inflation and output can only be predicted with some uncertainty. Given inflation, output, and the federal funds rate in year t, the two-year inflation forecast (predicted inflation for the period beginning in one year and ending in two years), $\pi_{t+2|t}$, will be given by

$$\pi_{t+2|t} = \pi_t + \alpha(1+\beta_1)y_t - \alpha\beta_2(i_t - \pi_t). \tag{4}$$

Actual inflation in year *t+2* will differ from the forecast because of the supply and demand shocks that occur in year *t+1* and *t+2*,

$$\pi_{t+2} = \pi_{t+2|t} + (\varepsilon_{t+1} + \alpha\eta_{t+1} + \varepsilon_{t+2}). \tag{5}$$

John Taylor recommends a long-run inflation target for the central bank. Let π^* denote this long-run inflation target (for instance, 2 percent per year). Let the central bank's preferences over short-run fluctuations of inflation and output be captured by the quadratic loss function

$$L_t = (\pi_t - \pi^*)^2 + \lambda y_t^2, \tag{6}$$

where $\lambda \geq 0$ denotes the weight on output stabilization around the natural output level relative to inflation stabilization around the long-run inflation target. In line with John Taylor's recommendation, there is no long-run output target separate from the natural output level. If the weight λ is zero, there is a *single goal* for monetary policy in that only inflation enters in the loss function. If the weight is positive, there are *multiple goals* for monetary policy, in that output enters beside inflation in the loss function.

A rule for the inflation forecast

What does the optimal monetary policy look like? We can find it by minimizing the expected discounted sum of future loss functions. The appendix reports the details.

The case of a single goal, when the weight on output stabilization is zero, is easiest to examine. Then a necessary and sufficient condition for the optimal monetary policy is that the two-year inflation forecast equals the inflation target,

$$\pi_{t+2|t} = \pi^*. \tag{7}$$

Thus, the central bank should take the two-year inflation forecast to be its intermediate target, and it should adjust the instrument so as to always make the forecast equal to the inflation target. If the inflation forecast is above (below) the inflation target, the central bank should increase (decrease) the federal funds rate to make the forecast equal the target.

Ex post, due to the shocks, some deviations of actual inflation from the inflation target are inevitable. The best the central bank can do to minimize deviations from the target is to assure that the inflation forecast is right on target.

The case of multiple goals, when the weight on output stabilization is positive, also has a simple and intuitive interpretation (although, as the appendix demonstrates, it is a little more complicated to derive). Then, instead of adjusting the two-year inflation forecast all the way to the inflation target, the central bank should let it return gradually to the long-run inflation target. More precisely, the two-year inflation forecast should be a weighted average of the long-run inflation target and the one-year inflation forecast, $\pi_{t+1|t}$, according to

$$\pi_{t+2|t} = c\pi^* + (1-c)\pi_{t+1|t}, \tag{8}$$

where the coefficient *c*, the rate of adjustment toward the long-run target, is between zero and one. (The one-year inflation forecast is predetermined; it is determined by previous policy and the shocks that have occurred, and therefore, beyond the control of the central bank.) We can interpret this as implying a variable short-run target for the two-year inflation forecast.

The intuition for this is that adjusting the two-year inflation forecast all the way to the long-run inflation target, regardless of the one-year inflation forecast, may require considerable output fluctuations. If there is a positive weight on output stabilization, a gradual adjustment of the two-year inflation forecast toward the long-run inflation target is better, since it requires less output fluctuations.

The higher the weight on output stabilization, the slower the adjustment of the inflation forecast toward the long-run inflation target (the smaller the coefficient *c*).

The optimal policy is thus a steady leaning toward the long-run inflation target, very different from the so-called opportunistic approach to disinflation discussed in Orphanides and Wilcox (1996) and in Rudebusch (1996).

An ideal intermediate target

Thus, the above analysis implies that the central bank should consider its inflation forecast for the control lag as an intermediate target, and adjust the instrument so that the inflation forecast is either always on the long-run inflation target (when there is a zero weight on output stabilization) or gradually approaches the long-run inflation target (when there is a positive weight on output stabilization). As I have argued more fully elsewhere in Svensson (1996a), the inflation forecast is indeed an ideal intermediate target. It is the current variable that by definition has the highest correlation with the goal, future inflation. It is easier to control than the goal, since various supply and demand shocks enter in the latter. It is easier to observe than the goal, since it depends on current variables, whereas one has to wait some two years to observe realized inflation. The principles of inflation forecast targeting are highly transparent and intuitive, which I hope the above discussion has demonstrated. Also, inflation forecast targeting is incentive compatible, in the sense that it gives the central bank strong incentives to learn how to control inflation, by improving its modeling, forecasting, and information collecting. With transparency and openness by central banks toward the public, the public then has the best possibilities to understand, evaluate, and monitor monetary policy. The increasingly informative *Inflation Reports* regularly issued by inflation-targeting central banks are examples of such improved transparency.

Response to shocks

How should monetary policy react to shocks? The conventional wisdom is that monetary policy should neutralize aggregate demand shocks, since these move inflation and output in the same direction. With regard to supply shocks, the conventional wisdom is that the response depends on the weight on output stabilization. With a positive weight, it is optimal to partially accommodate supply shocks, since they affect inflation and output in opposite directions. With a zero weight, the supply shock effect on inflation is neutralized, even though this enhances the effect on output.

When lags are taken into account, the conventional wisdom must be modified. First, because of the lags, the central bank cannot affect the first-round effects on inflation and output of supply and demand shocks. Second, the lagged monetary policy reaction to demand and supply shocks are more symmetric. Third, the reaction to both shocks differ with the weight on output stabilization. With a zero weight on output stabilization, regardless of how the shocks have affected the one-year inflation forecast, the two-year inflation forecast is brought in line with the long-run inflation target. Hence, shocks are not allowed to let the two-year inflation forecast deviate from the long-run target. With a positive weight, the two-year inflation forecast is adjusted due to the shocks. The effect of these shocks on future inflation is only gradually eliminated.

Target rules vs. instrument rules

Setting the instrument to make the inflation forecast equal to the inflation target is an example of a *target rule* which, if applied by the monetary authority, would result in an endogenous optimal reaction function expressing the instrument as a function of the available relevant information. This is different from an *instrument rule* that directly specifies the reaction function for the instrument in terms of current information. I interpret John Taylor's discussions of instrument rules as advocating instrument rules rather than target rules.[2]

Setting the instrument so as to fulfill the target rules (equations 7 or 8) results in an endogenous instrument rule corresponding to inflation targeting. Since the current information in the model is inflation and output, the instrument rule will be of the same type as discussed by John Taylor in the references I cite of his work,

$$i_t = \pi_t + h(\pi_t - \pi^*) + gy_t. \tag{9}$$

The above target rule in equation 8 depends only on the parameters in the Phillips curve and the central bank's loss function. The single-goal target rule in equation 7 depends on the long-run inflation target only. In contrast, the instrument rule also depends on the aggregate demand function. (The appendix shows that the coefficients g and h depend on all the parameters of the model.) Therefore, the target rules (equations 7 or 8) are less complex and more robust than the instrument rule in equation 9. In the real world, much different information is relevant to forecast inflation; the instrument rule is, in principle, a complicated function of all such information, not just a few macrovariables.

I consider a commitment to a target rule to be a more advantageous arrangement than a commitment to an instrument rule. A target rule focuses on the essential, that is, to achieve the goal, and allows more flexibility in finding the corresponding reaction function. More specifically, with new information about structural relationships, such as changes in exogenous variables, a target rule implies automatic revisions of the reaction function. A commitment to an explicit instrument rule either requires more confidence in the structural model and its stability, or frequent revision that may be difficult to motivate and hence less transparent. Target rules are inherently more stable than instrument rules, and easier to identify, motivate, and verify.[3]

Price level targeting vs. inflation targeting

Let me refer to a monetary policy regime as *price level targeting* or *inflation targeting*, depending upon whether the goal is a stable price level or a low and stable inflation rate, where the latter allows base drift of the price level. Base drift in the price level implies that the price level becomes non-trend-stationary, and the variance of the future price level increases without bounds with the forecast horizon. This is obviously rather far from literal price stability.

In the real world, there are currently several monetary policy regimes with explicit or implicit inflation targeting (see Haldane, 1996, and Leiderman and Svensson, 1995), but there are no regimes with explicit or implicit price level targeting. Whereas the gold standard may be interpreted as implying implicit price level targeting, so far the only regime in history with explicit price level targeting may have been Sweden during the short but successful period 1931-33. (See Fisher, 1934, and also Jonung, 1979.)

Even if there are no current examples of price level targeting regimes, price level targeting has received increasing interest in the monetary policy literature. At the Federal Reserve Bank of Kansas City's Jackson Hole symposium in 1984, Robert Hall argued for price level targeting. Several recent papers compare inflation targeting and price level targeting, some of which are collected in Bank of Canada (1994). Some papers compare inflation and price level targeting by simulating the effect of postulated reaction functions. Other papers compare the properties of postulated simple stochastic processes for inflation and the price level (see, for example, Fischer, 1994). A frequent result, emerging as the conventional wisdom, is that the choice between price level targeting and inflation targeting involves a tradeoff between low-frequency price level uncertainty on the one hand and high-frequency inflation and output uncertainty on the other. Thus, price level targeting has the advantage of reduced long-term variability of the price level. This should be beneficial for long-term nominal contracts and intertemporal decisions, but it comes at the cost of increased short-term variability of inflation and output. The intuition is straightforward: In order to stabilize the price level under price level targeting, higher-than-average inflation must be succeeded by lower-than-average inflation. This should result in higher inflation variability than inflation targeting, since base level drift is accepted in the latter case and higher-than-average inflation need only be succeeded by average inflation. Via nominal rigidities, the higher inflation variability should then result in higher output variability.

Applying postulated monetary policy reaction functions, instrument rules, evokes the issue of whether these reaction functions are optimal for reasonable objective functions of the central bank. Also, such reaction functions may not be consistent with the realistic situation when the central bank acts under discretion because commitment to an optimal or a simple second-best rule is not possible. Similarly, applying postulated stochastic processes for inflation and the price level evokes the issue of whether these are consistent with a reasonable equilibrium.

In Svensson (1996c), I compare price level and inflation targeting, but I depart from the previous literature on price level versus inflation targeting by applying a principal-agent approach: the decision rules considered are the *endogenous* decision rules that result when society (the principal) assigns (delegates) an inflation target or a price level target to a central bank (the agent) acting under discretion. The reaction functions are hence endogenous, given central bank objectives and constraints, including available commitment technology.

Output and employment are, realistically, considered to be persistent. The degree of persistence in employment is indeed crucial for the results: Without persistence, a trivial tradeoff between long-term price level variability and short-term inflation variability arises. With at least moderate persistence, counter to the conventional wisdom, there is *no* tradeoff between price level variability and inflation variability. Price level targeting then results in *lower* inflation variability than inflation targeting. This result is due to the endogenous decision rule that results under discretion for different targets. Under inflation targeting, the decision rule is a linear feedback rule for inflation on employment. Then the variance of inflation is proportional to the variance of employment. Under price level targeting, the decision rule is a linear feedback rule for the *price level* on employment. Then inflation, the change in the price level, is a linear function of the *change* in employment. The variance of inflation is then proportional to the variance of the change in employment. With at least moderate persistence, the variance of the change in employment is less than the variance of employment.

In addition, a price level target has the advantage of eliminating any inflation bias that results under discretion if the employment target exceeds the natural rate of employment. It is replaced by a harmless price level bias. Indeed, with at least moderate persistence, even if society prefers to minimize inflation variability rather than price level variability, it will be better off by assigning a price level target to the central bank rather than an inflation target. The variance of inflation will be lower, there is no inflation bias, and with expectations incorporating price level targeting, employment variability will be the same as under inflation targeting.

I believe these results show that the relative benefits of price level targeting and inflation targeting are far from settled. However, I believe that inflation targeting is a sufficiently ambitious undertaking for central banks as of now. Once central banks have mastered inflation targeting, in perhaps another five or ten years, it may be time to increase the ambitions and consider price level targeting. By then we should know more about which regime is preferable.

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Appendix

The model is described by the equations

(A1) $$\pi_{t+1} = \pi_t + \alpha y_t + \varepsilon_{t+1}$$

(A2) $$y_{t+1} = \beta_1 y_t - \beta_2(i_t - \pi_t) + \eta_{t+1},$$

where ε_t and η_t are i.i.d. disturbances.

The intertemporal loss function is

(A3) $$E_t \sum_{r=0}^{\infty} \delta^r L(\pi_{t+r}, y_{t+r}),$$

where δ $(0<\delta<1)$ is a discount factor, the period loss function is

(A4) $$L(\pi_t, y_t) = (\pi_t - \pi^*)^2 + \lambda y_t^2,$$

and $\lambda \geq 0$ is the relative weight on output stabilization.

One-year control lag

In order to solve the model it is practical to first study the simpler problem

(A5) $$V(\pi_t) = \min_{y_t} \left[(\pi_t - \pi^*)^2 + \lambda\, y_t^2 + \delta E_t V(\pi_{t+1})\right]$$

subject to

(A6) $$\pi_{t+1} = \pi_t + \alpha y_t + \varepsilon_{t+1},$$

where output y_t is regarded as a control variable and there is only a one-year control lag for inflation.

The indirect loss function $V(\pi_t)$ will be quadratic,

$$V(\pi_t) = k_0 + k\,(\pi_t - \pi^*)^2\,, \tag{A7}$$

where the coefficients k_0 and k remain to be determined. The first-order condition is

$$2\lambda y_t + \delta E_t V_\pi(\pi_{t+1})\alpha = 2\lambda y_t + 2\delta\alpha k\,(\pi_{t+1|t} - \pi^*) = 0, \tag{A8}$$

where I have used equation A7 and $\pi_{t+r|t} = E_t\pi_{t+r}$. This can be written

$$\pi_{t+1|t} - \pi^* = -\frac{\lambda}{\delta\alpha k}\,y_t\,. \tag{A9}$$

The decision rule for output fulfills

$$\begin{aligned} y_t &= -\frac{\delta\alpha k}{\lambda}\,(\pi_{t+1|t} - \pi^*) \\ &= -\frac{\delta\alpha k}{\lambda + \delta\alpha^2 k}\,(\pi_t - \pi^*)\,, \end{aligned} \tag{A10}$$

where I have used that by equation A6

$$\pi_{t+1|t} = \pi_t + \alpha y_t\,. \tag{A11}$$

Then the equilibrium inflation forecast fulfills

$$\begin{aligned} \pi_{t+1|t} = \pi_t + \alpha y_t &= \pi^* + \left(1 - \frac{\delta\alpha^2 k}{\lambda + \delta\alpha^2 k}\right)(\pi_t - \pi^*) \\ &= \pi^* + \frac{\lambda}{\lambda + \delta\alpha^2 k}\,(\pi_t - \pi^*). \end{aligned} \tag{A12}$$

In order to identify k I exploit the envelope theorem for equations A5 and A7 and use equation A12, which gives

$$V_\pi(\pi_t) = 2k\,(\pi_t - \pi^*) = 2\,(\pi_t - \pi^*) + 2\delta k\,(\pi_{t+1|t} - \pi^*)$$

$$= 2\left(1 + \frac{\delta\lambda k}{\lambda + \delta\alpha^2 k}\right)(\pi_t - \pi^*)\,. \tag{A13}$$

Identification of the coefficient for $\pi_t - \pi^*$ gives

$$k = 1 + \frac{\delta\lambda k}{\lambda + \delta\alpha^2 k}\,. \tag{A14}$$

The right-hand side is equal to unity for *k=0* and increases toward $1 + \frac{\lambda}{\alpha^2}$ for $k \to \infty$. We realize that there is a unique positive solution that fulfills $k \geq 1$. It can be solved analytically:

$$k^2 - \left(1 - \frac{\lambda(1-\delta)}{\delta\alpha^2}\right) k - \frac{\lambda}{\delta\alpha^2} = 0,$$

$$k = \frac{1}{2}\left(1 - \frac{\lambda(1-\delta)}{\delta\alpha^2} + \sqrt{\left(1\ \frac{\lambda(1-\delta)}{\delta\alpha^2}\right)^2 + \frac{4\lambda}{\delta\alpha^2}}\right)$$

$$= \frac{1}{2}\left(1 - \frac{\lambda(1-\delta)}{\delta\alpha^2} + \sqrt{\left(1\ \frac{\lambda(1-\delta)}{\delta\alpha^2}\right)^2 + \frac{4\lambda(1-\delta)}{\delta\alpha^2} + \frac{4\lambda}{\alpha^2}}\right)$$

$$= \frac{1}{2}\left(1 - \frac{\lambda(1-\delta)}{\delta\alpha^2} + \sqrt{\left(1\ \frac{\lambda(1-\delta)}{\delta\alpha^2}\right)^2 + \frac{4\lambda}{\alpha^2}}\right) \geq 1. \tag{A15}$$

Two-year control lag

After these preliminaries, consider the problem

$$\min_{i_t} E_t \sum_{r=0}^{\infty} \delta^r L\,(\pi_{t+r}, y_{t+r}) \tag{A16}$$

subject to equations A1 and A2. We realize that this can be formulated as

$$V(\pi_{t+1|t}) = \min_{y_{t+1|t}} \left[(\pi_{t+1|t} - \pi^*)^2 + \lambda y_{t+1|t}^2 + \delta E_t V(\pi_{t+2|t+1}) \right] \tag{A17}$$

subject to

$$\begin{aligned} \pi_{t+2|t+1} &= \pi_{t+1} + \alpha y_{t+1} \\ &= \pi_{t+1|t} + \alpha y_{t+1|t} + (\varepsilon_{t+1} + \alpha \eta_{t+1}), \end{aligned} \tag{A18}$$

where $y_{t+1|t}$ is regarded as the control, and where the optimal federal funds rate can be inferred from

$$i_t - \pi_t = -\frac{1}{\beta_2} y_{t+1|t} + \frac{\beta_1}{\beta_2} y_t. \tag{A19}$$

This problem is analogous to the problem in equation A5 subject to equation A6. Thus, in analogy with equation A9, the first-order condition can be written

$$\pi_{t+2|t} - \pi^* = -\frac{\lambda}{\delta \alpha k}\, y_{t+1|t}, \tag{A20}$$

and the reaction function will fulfill

$$\begin{aligned} i_t - \pi_t &= -\frac{1}{\beta_2} y_{t+1|t} + \frac{\beta_1}{\beta_2} y_t = \frac{\delta \alpha k}{\lambda \beta_2} (\pi_{t+2|t} - \pi^*) + \frac{\beta_1}{\beta_2} y_t \\ &= \frac{\delta \alpha k}{\lambda \beta_2} \left[\pi_t - \pi^* + \alpha(1 + \beta_1) y_t - \alpha \beta_2 (i_t - \pi_t) \right] + \frac{\beta_1}{\beta_2} y_t \\ &= h\,(\pi_t - \pi^*) + g y_t, \end{aligned} \tag{A21}$$

where

$$h = \frac{\delta\alpha k}{\beta_2(\lambda + \delta\alpha^2 k)} \text{ and } g = \frac{1}{\beta_2}\left(\frac{\delta\alpha^2 k}{\lambda + \delta\alpha^2 k} + \beta_1\right), \tag{A22}$$

and where I have used

$$\pi_{t+2|t} = \pi_t + \alpha(1+\beta_1)\, y_t - \alpha\beta_2(i_t - \pi_t), \tag{A23}$$

and where k will obey equation A15.

Since by equation A1 we have

$$y_{t+1|t} = \frac{1}{\alpha}\left(\pi_{t+2|t} - \pi_{t+1|t}\right), \tag{A24}$$

we can eliminate $y_{t+1|t}$ from equation A20 and get, after some algebra,

$$\pi_{t+2|t} = c\pi^* + (1 - c)\pi_{t+1|t}, \tag{A25}$$

where

$$0 < c = \frac{\delta\alpha^2 k}{\lambda + \delta\alpha^2 k} \leq 1. \tag{A26}$$

The coefficient $\frac{\lambda}{\delta\alpha k}$ in equation A20 will be (i) increasing in λ and (ii) decreasing in α. Then c in equation A25 will be (i) decreasing in λ and (ii) increasing in α. To show (i), consider

$$\begin{aligned} z = \frac{k}{\lambda} &= \frac{1}{2}\left[\frac{1}{\lambda} - \frac{1-\delta}{\delta\alpha^2} + \sqrt{\left(\frac{1}{\lambda} + \frac{1-\delta}{\delta\alpha^2}\right)^2 + \frac{4}{\lambda\alpha^2}}\right] \\ &= \frac{1}{2}\,[w - A + \sqrt{(w + A)^2 + 4ABw}], \end{aligned} \tag{A27}$$

where

(A28) $$w = \frac{1}{\lambda},\ A = \frac{1-\delta}{\delta\alpha^2} > 0,\ B = \frac{\delta}{1-\delta} > 0.$$

It is straightforward to show that $\frac{\partial z}{\partial w} > 0$, hence that $\frac{\partial(k/\lambda)}{\partial\lambda} < 0$, and $\frac{\partial(\lambda/k)}{\partial\lambda} > 0$. To show (ii), consider

(A29) $$v = \alpha k = \frac{1}{2}\left[\alpha - \frac{D}{\alpha} + \sqrt{\left(\alpha + \frac{D}{\alpha}\right)^2 + 4\lambda}\right],$$

where

(A30) $$D = \frac{\lambda(1-\delta)}{\delta} > 0.$$

It is sufficient to show that $\frac{\partial v}{\partial\alpha} > 0$. Thus,

$$2\frac{\partial v}{\partial\alpha} = 1 + \frac{D}{\alpha^2} + \frac{2(1+\frac{D}{\alpha^2})\alpha(1-\frac{D}{\alpha^2})}{\sqrt{2(\alpha+\frac{D}{\alpha})^2 + 4\lambda}} = (1+\frac{D}{\alpha^2})\ (1 + \frac{\alpha - \frac{D}{\alpha}}{\sqrt{(\alpha+\frac{D}{\alpha})^2 + 4\lambda}})$$

(A31) $$= 1 + \frac{D}{\alpha^2} + \frac{\sqrt{(\alpha+\frac{D}{\alpha})^2 + 4\lambda} + (\alpha - \frac{D}{\alpha})}{\sqrt{(\alpha+\frac{D}{\alpha})^2 + 4\lambda}} > 0.$$

It follows that *c* decreases monotonically from 1 toward 0 when λ goes from 0 to infinity.

Endnotes

[1]Similar ideas about inflation targeting are independently expressed in Haldane (1996). Some additional issues, including model uncertainty, are examined in Svensson (1996b).

[2]In several papers, for instance, McCallum (1990) has argued for an instrument rule in the form of a monetary base rule.

[3]In Svensson (1996a), I extend on how the public can monitor the target rules for inflation targeting.

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