UNDERSTANDING THE OPPORTUNISTIC APPROACH TO DISINFLATION[‡]

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Abstract

One approach to achieving price stability is to undertake a deliberate path to an ultimate goal of low inflation - deliberate disinflation. In contrast an opportunistic strategy for disinflation has gained credence in recent years. We compare the ability of the two approaches to achieve macroeconomic stability and conclude that the opportunistic approach is sub-optimal when a commitment mechanism is in place. We show that an opportunistic inflation response is however optimal when there is a nonlinearity of the Phillips curve trade-off along with adaptive expectations- circumstances that appear unlikely in conditions of low inflation.

JEL classifications: E52; E58

Keywords: Deliberate disinflation; Opportunistic disinflation; Loss function

[‡]We thank Romer Correa, Veena Mishra and participants at The Fifth Annual Conference on Money and Finance, 30-1th February 2003, IGIDR, India, for helpful comments.

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I **Introduction**

Central banks in different countries have adopted different strategies for achieving price stability. During the 1990s several countries have introduced explicit inflation targets.[1] One approach to price stability is to take a *deliberate* path to an ultimate goal of low inflation. In contrast, an *opportunistic* disinflation strategy specifies both an *interim* as well as a *long-run* goal for price stability. Proponents of this approach hold that when inflation is moderate but still above the central bank's long-run inflation objective, policymakers should not take deliberate anti-inflation action, but rather should wait for favourable supply shocks and unforeseen recessions to deliver the desired reduction in inflation. This strategy has gained support among some prominent central bankers and academics in recent years.[2]

Commenting on the FOMC's strategy in the 1990s, Alan Blinder (1997) writes *"Under certain circumstances, the optimal disinflation strategy is asymmetric in the following specific way: you guard vigorously against any rise in inflation, but wait patiently for the next favourable inflation shock to bring inflation down. The opportunistic strategy makes the time needed to approach the ultimate inflation target a random variable. When I was the Vice Chairman of the Fed, I often put it this way: the United States is "one recession away" from price stability."*

[1] For an in-depth analysis see Bernanke et al. (1999).

[2] For academic work on this topic see Orphanides and Wilcox (1996), Orphanides et al. (1997) and Bomfim and Rudebusch (2000).

Explaining the opportunistic disinflation strategy Governor Laurence Meyer (1996) notes *"Under this strategy, once inflation becomes modest, as today, Federal Reserve policy in the near term focuses on sustaining trend growth at full employment at the prevailing inflation rate. At this point the short-run priorities are twofold: sustaining the expansion and preventing an acceleration of inflation. This is, nevertheless, a strategy for disinflation because it takes advantage of the opportunity of inevitable recession and potential positive supply shocks to ratchet down inflation over time."*

In this paper we compare the ability of the two approaches to achieve macroeconomic stability (measured in terms of inflation and output variability) when a policymaker commits to a particular strategy. We assume commitment on the assumption that the central bank has full political backing for the policy of inflation control and faces no pressure to use monetary policy to raise the long-run employment rate; this is the usual framework within which opportunism is discussed. The key difference between a deliberate and an opportunistic policymaker is in the reaction to deviations of inflation from target. First, while the deliberate policymaker reacts to the gap between actual inflation and a long-run target, the opportunistic policymaker reacts to the gap between actual inflation and an interim target. Second, while the deliberate policymaker responds to the inflation gap in a linear manner, the opportunistic policymaker's reaction to the gap between actual inflation and the interim target is nonlinear. We demonstrate that such asymmetries result in higher inflation variability under commitment in spite of zero inflation bias.[3] A further question of interest is what considerations could motivate the policymaker to adopt an objective function with these characteristics; hitherto such models have been studied by assuming that expectations are adaptive. Specifically we show that a nonlinear effect of the shock on the position of the Phillips curve trade-off along with adaptive expectations provides an optimally opportunistic inflation response.

The rest of the paper is organised as follows. In section II we review the usual deliberate approach to disinflation under commitment. This is followed by the derivation of the optimal inflation response under commitment when a policymaker is opportunistic in section III, which includes a comparison of the two strategies. In section IV we explore the economic rationale for opportunism and conclude that it is motivated by political economy considerations. Section V concludes the paper.

II **Deliberate strategy under commitment**

There is by now widespread agreement among central bankers and academics alike that inflation targeting in practice is 'flexible' inflation targeting. The central bank's objective is not only to stabilize inflation around an exogenously specified target, but also to put some weight on stabilizing the output gap.[4] There is also general agreement that inflation-targeting central banks do not have overambitious output

[3] Bomfim and Rudebusch (2000) explore the role of imperfect credibility and opportunism in a model with adaptive expectations and conclude that opportunism is sub-optimal.

[4] A positive weight on the output gap is generally considered to be consistent with the mandate

targets. Hence, discretionary optimization *à la* Kydland and Prescott (1977) or Barro and Gordon (1983), does not result in average inflation bias (see Blinder, 1997).

(i) Deliberate strategy under commitment

The treatment of deliberate inflation targeting under commitment follows Svensson (1997), which in turn builds on the recent extensions of the analysis of rules and discretion in monetary policy in Lockwood et al. (1995).

The short-run Phillips curve is

$$y_t = \rho y_{t-1} + \alpha \left(\pi_t - \pi_t^e\right) + \varepsilon_{t,} \tag{2.1}$$

where y_t is the output gap in period t, α and ρ are constants ($\alpha > 0$ and $0 < \rho < 1$), π_t is the inflation rate, π_t^e denotes expectations conditional upon information available in period $t-1$, and ε_t is iid error, normally distributed with mean zero and variance σ_ε^2. The private sector has rational expectations; that is,

$$\pi_t^e = E_{t-1}\pi_t, \tag{2.2}$$

Now suppose that there is a commitment mechanism, so that the central bank can commit to the optimal rule. Under commitment, the optimal rule under inflation targeting is

$$\pi_t = \pi_t^e + b\varepsilon_{t,} \tag{2.3}$$

of many central banks not only to maintain price stability but also to facilitate economic growth over time.

where, inflation is independent of the lagged output gap and only depends on the new information that has arrived after the private sector formed its expectations. When the central bank is committed to a state-contingent rule in conducting monetary policy, this implies that the monetary authority internalizes the impact of its decision rule on the expectations of the private sector. In other words, the monetary authority takes into account how its actions affect the private sector's expectations. It does this by minimizing its loss function with respect to the private sector's expectations of the inflation rate under the explicit constraint that these expectations are formed rationally.

Thus, (2.1), (2.2) and (2.3) represent the constraints facing the central bank. The central bank's objective under deliberate disinflation strategy is to stabilize inflation around a given (long-run) inflation target, $\pi^{\star}$, as well as stabilizing the output gap around an output gap target, $y^{\star} = 0$. This can be represented by an intertemporal loss function for the central bank given by

$$E_t \left[\sum_{\tau=t}^{\infty} \beta^{\tau-t} L_{\tau} \right], \tag{2.4}$$

with the period loss function

$$L_t = \frac{1}{2} \left[(\pi_t - \pi^{\star})^2 + \lambda (y_t - y^{\star})^2 \right], \tag{2.5}$$

where $\lambda > 0$ is the relative weight on output-gap stabilization. The central bank is, for simplicity, assumed to have perfect control over the inflation rate π_t. It sets the inflation rate in each period after having observed the current supply shock ε_t. This is a dynamic programming problem with one state variable, y_{t-1}, and two control variables, π_t and π_t^e, and where β is the discount factor.[5] The solution can be obtained by solving the following equation involving the value function $V(y_t)$. Thus, the decision problem of the central bank can be expressed as

$$V(y_{t-1}) = E_{t-1} \min_{\pi_t^e,\, \pi_t} \left\{ \frac{1}{2} \left[(\pi_t - \pi^\star)^2 + \lambda (y_t - y^\star)^2 \right] + \beta V(y_t) \right\}, \tag{2.6}$$

where the minimization in period t is subject to (2.1)-(2.3). For the linear-quadratic problem such as ours, $V(y_t)$ must also be quadratic. Thus, the indirect loss function can be written as

$$V(y_{t-1}) = \gamma_0 + \gamma_1 y_{t-1} + \frac{1}{2}\gamma_2 y_{t-1}^2, \tag{2.7}$$

so that $V'(y_{t-1}) = \gamma_1 + \gamma_2 y_{t-1}$ and $\gamma_i's$ are the undetermined coefficients. Using this condition together with Eqs. (2.1)-(2.3), we obtain two first-order conditions from Eq. (2.6) with respect to π_t^e and π_t, respectively:

$$E_{t-1}\pi_t = \pi^\star \tag{2.8}$$

$$\mu = -(\pi_t - \pi^\star) - \lambda\alpha (y_t - y^\star) - \alpha\beta [\gamma_1 + \gamma_2 (y_t - y^\star)] \tag{2.9}$$

[5] Note that if there is no output persistence, the problem of minimizing the intertemporal loss function Eq. (2.4) is equivalent to the static problem of minimizing the expected period loss function Eq. (2.5).

where μ is the Lagrangian multiplier on the joint constraint (2.2) and (2.3): $\mu(\pi_t - E_{t-1}\pi_t + b\varepsilon_t)$. Taking expectations of (2.9) and substituting (2.8) for $E_{t-1}\pi_t$ implies that

$$\mu = -\lambda\alpha(\rho y_{t-1} - y^\star) - \alpha\beta[\gamma_1 + \gamma_2(\rho y_{t-1} - y^\star)] \tag{2.10}$$

Substituting (2.10) in (2.9) for μ yields:

$$\pi_t = \pi^\star - \left[\frac{\alpha(\beta\gamma_2 + \lambda)}{1 + \alpha^2(\beta\gamma_2 + \lambda)}\right]\varepsilon_t \tag{2.11}$$

Eq. (2.11) is the optimal feedback rule for inflation under commitment expressed as a function of the parameters of the model and the coefficient, γ_2, which can be easily derived by making use of the Envelope theorem. Differentiating Eq. (2.6) w.r.t y_{t-1} yields:

$$V'(y_{t-1}) = \gamma_1 + \gamma_2 y_{t-1} = \rho\lambda(\rho y_{t-1} - y^\star) + \beta\rho[\gamma_1 + \gamma_2(\rho y_{t-1} - y^\star)] \tag{2.12}$$

Collecting terms in γ_2 yields:

$$\gamma_2 = \frac{\lambda\rho^2}{1 - \beta\rho^2} \tag{2.13}$$

Therefore, the solution for inflation and output gap under a deliberate strategy can be expressed as:

$$\pi_t = \pi^\star - \left[\frac{\alpha\lambda}{1 - \beta\rho^2 + \alpha^2\lambda}\right]\varepsilon_t \tag{2.14}$$

$$y_t = \rho y_{t-1} + \left[\frac{1 - \beta\rho^2}{1 - \beta\rho^2 + \alpha^2\lambda}\right]\varepsilon_t \tag{2.15}$$

where the average inflation bias, $E(\pi_t) - \pi^\star = 0$ i.e., there is no average inflation bias with a deliberate strategy under commitment. The unconditional variability of both output and inflation will be proportional to the variance of the supply shock.

III **Opportunistic strategy under commitment**

In contrast to a deliberate policymaker the opportunistic policymaker reacts to the gap between actual inflation and an interim target. He guards against any incipient rise in the interim target for inflation (π_t^T), but waits for the next favourable inflation shock to lower the interim target, rather than seeking to actively lower the interim target towards the long-run target $(\pi^\star)$. This difference in policy responsiveness invariably suggests a nonlinearity in the policy response function. In this section we show that the opportunistic policymaker can be thought of as rationally optimising a welfare function in which the inflation target is an interim one. We later discuss how such a set-up could be justified as welfare-maximising. We extend the standard analysis of the previous section by assuming that the interim target for inflation depends on the realisation of supply shocks. Thus, the opportunistic policymaker is assumed to minimise

$$V(y_{t-1}) = E_{t-1} \min_{\pi_t^e,\, \pi_t} \left\{ \frac{1}{2} \left[\left(\pi_t - \pi_t^T \right)^2 + \lambda (y_t - y^\star)^2 \right] + \beta V(y_t) \right\}, \qquad (3.1)$$

where π_t^T is the interim target for inflation and $V(y_t)$ is defined in Eq. (2.7). In addition the model includes an equation describing the determination of the intermediate target as a function of the underlying supply shock and a weighted average of past inflation and the long-run target for inflation. In other words we assume that policymakers incentive to deflate is a nonlinear function of the underlying supply shock i.e.,

$$\Delta\pi_t^T = -\delta\left(e^{\gamma\varepsilon_{t-1}}\right) - \phi\left(\pi_{t-1}^T - \pi^\star\right) + \delta\left(e^{\frac{\gamma^2\sigma_\varepsilon^2}{2}}\right)$$

or

$$\pi_t^T = \pi^\star - \delta\sum_{i=0}^{\infty}(1-\phi)^i e^{\gamma\varepsilon_{t-1-i}} + \frac{\delta}{\phi}\left(e^{\frac{\gamma^2\sigma_\varepsilon^2}{2}}\right) \quad (3.2)$$

where δ, ϕ, $\gamma > 0$. Thus, the intermediate target always lies between the inherited inflation target (π_{t-1}^T) and the long-run target ($\pi^\star$).[6] Note that the opportunistic central banker reacts asymmetrically to supply shocks. Figure 1 plots Eq. (3.2) for $\delta = 0.1$ and for $\gamma = 1.5$ (assuming that $\phi = 0$). The x-axis plots both positive and negative deviations of supply shocks while the y-axis plots the implied change in the interim target for inflation. It is clear from the figure that when there is a positive supply shock the interim target for inflation is adjusted downwards while it stays put when we have negative supply shocks.[7] Also note from Eq. (3.2) that in the long-run the interim target converges to the long-run target i.e., when supply shocks are zero,

[6] The key feature of the interim target is that it exhibits path dependence i.e., allows the policymaker to react differently to a given level of inflation depending on the prior history of inflation itself (see Orphanides and Wilcox, 1996).

[7] Note that the constant term $\delta\left(e^{\frac{\gamma^2\sigma_\varepsilon^2}{2}}\right)$ in Eq. (3.2) just shifts Figure 1 upwards.

$\pi_t^T = \pi^\star$.

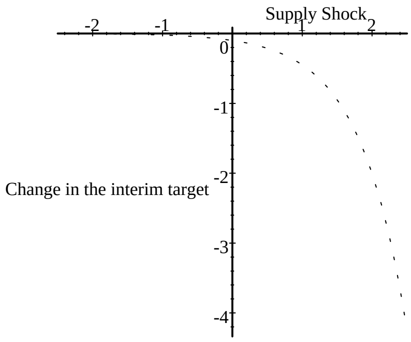

Figure 1: **Change in the Interim Target for Inflation**

Using (3.2) together with Eqs. (2.1)-(2.3), we obtain two first-order conditions under commitment from Eq. (3.1) with respect to π_t^e and π_t, respectively:

$$E_{t-1}\pi_t = E_{t-1}\pi_t^T = \pi^\star - \delta \sum_{i=0}^{\infty} (1-\phi)^i e^{\gamma\varepsilon_{t-1-i}} + \frac{\delta}{\phi}\left(e^{\frac{\gamma^2\sigma_\varepsilon^2}{2}}\right) \tag{3.3}$$

$$\mu_1 = -\left(\pi_t - \pi_t^T\right) - \lambda\alpha\left(y_t - y^\star\right) - \alpha\beta\left[\gamma_1 + \gamma_2\left(y_t - y^\star\right)\right] \tag{3.4}$$

where μ_1 is the Lagrangian multiplier. Taking expectations of (3.4) and substituting (3.3) for $E_{t-1}\pi_t$ implies that

$$\mu_1 = -\lambda\alpha\left(\rho y_{t-1} - y^\star\right) - \alpha\beta\left[\gamma_1 + \gamma_2\left(\rho y_{t-1} - y^\star\right)\right] \tag{3.5}$$

Substituting (3.5) in (3.4) for μ_1 yields:

$$\pi_t = \phi\pi^\star + (1-\phi)\pi_{t-1}^T - \delta\left(e^{\gamma\varepsilon_{t-1}}\right) + \delta\left(e^{\frac{\gamma^2\sigma_\varepsilon^2}{2}}\right) - \left[\frac{\alpha\left(\beta\gamma_2 + \lambda\right)}{1 + \alpha^2\left(\beta\gamma_2 + \lambda\right)}\right]\varepsilon_t \tag{3.6}$$

where as before $\gamma_2 = \frac{\lambda\rho^2}{1-\beta\rho^2}$ is derived by exploiting the Envelope theorem. Eq.(3.6) is the optimal feedback rule for a opportunistic central banker under commitment expressed as a function of the parameters of the model and the coefficient, γ_2. Note that the average inflation bias under an opportunistic strategy is also zero,

$$E\left(\pi_t - \pi^{\star}\right) = -\delta E \sum_{i=0}^{\infty} \left(1-\phi\right)^i e^{\gamma \varepsilon_{t-1-i}} + \frac{\delta}{\phi}\left(e^{\frac{\gamma^2\sigma_\varepsilon^2}{2}}\right) = 0 \tag{3.7}$$

where $\pi_t = E_{t-1}\pi_t + b\varepsilon_t$.[8] To understand why, recall that the objective function of an opportunistic policymaker Eq.(3.1) is quadratic in spite of reacting asymmetrically to underlying shocks. In other words certainty equivalence still holds. However note that the unconditional variance of inflation (but not output) is higher under opportunism and as a result is sub-optimal from the point of view of welfare when defined according to our loss function Eq.(2.5) which we take throughout to be the true one.[9]

$$E\left(\pi_t - \pi^{\star}\right)^2 = \delta^2 e^{\gamma^2\sigma_\varepsilon^2}\left(\frac{\phi e^{\gamma^2\sigma_\varepsilon^2} - (2-\phi)}{\phi^2\left(2-\phi\right)}\right) + b^2\sigma_\varepsilon^2 \tag{3.8}$$

Note that the variance depends upon the asymmetry parameter 'γ'. Clearly inflation variance is higher as one increases 'γ', i.e. the more opportunistic the policymaker, the higher the inflation variance. These results arise in spite of policies being fully credible

[8] This derivation makes use of the result that where ϵ_t is normally distributed, as we assume throughout, the mean of a lognormal distribution $\exp(\epsilon_t)$ is $\exp \sigma_\epsilon^2$.

[9] See appendix for derivation of the unconditional variance of inflation.

and policymakers targeting potential output. The intution behind this results is that under a deliberate strategy inflationary expectations are anchored by $\pi^\star$. Whereas under opportunism inflationary expectations are random i.e., they vary with supply shocks. Consequently, actual inflation is more variable under opportunism. Thus, if the central bank's loss function is quadratic in inflation and output deviations but responds asymmetrically to supply shocks, the opportunistic approach to disinflation is not optimal. On the contrary, the policymaker should in that circumstance pursue the objective of price stability period by period, regardless of the underlying shock as long as inflation is above its long-run target. In light of the fact that this policy is sub-optimal, it is important to understand why policymakers would pursue it. The following section tries to address this issue.

IV **A Rationale for the opportunistic approach to disinflation**[10]

[10] We note that asymmetric *preferences* will deliver the asymmetric response we seek. But there appears to be no justification for such asymmetry. Rotemberg and Woodford (1999) for example argue that a quadratic (and so symmetric) loss function is an approximation of the true social welfare function; the reason is that a given absolute deviation of relative prices or of output from their natural rates creates an equal distortion whether positive or negative. Though this result is specific to their model with Calvo contracts, Minford and Nowell (2003) also find symmetry for a model with overlapping nominal contracts with endogenous indexation. In general, the representative agent's welfare depends on the variances (and maybe covariance) of consumption and leisure which will depend in turn on the variances of shocks and on the model (especially the policy) parameters:

The most important unresolved issue related to opportunism concerns the economic, welfare-based, rationale for an objective function such as Eqs. (3.1)-(3.2). In other words what considerations could rationally motivate a policymaker to adopt an objective function with these characteristics? Two arguments are cited in the literature as a justification for opportunism. The first concerns inflation expectations. When expectations are adaptive, inflation reduction requires a transitional cost in terms of lost output. Hence, authorities wait for favourable supply shocks to bring inflation down rather than engineer a downturn by pushing-up interest rates; in this way the transitional cost can be lowered or even eliminated as output need not fall below its natural rate. Orphanides et al. (1997) among others use this argument to justify an opportunistic strategy. Second, a nonlinear Phillips curve provides a partial rationale for opportunism even when the policymaker's preferences are quadratic (Orphanides and Wilcox (2000)). The point is that with a nonlinear Phillips curve the sacrifice ratio is not independent of the size of an intended change in inflation- it rises as the economy goes further into recession. This suggests that inflation should be reduced more when the economy is in an expansionary mode induced by favourable supply shocks. In what follows we investigate these arguments in turn and examine whether they rationalise opportunism.

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any transformation into terms of output and inflation will depend similarly on these variances and parameters. This implies symmetry in preferences, which we therefore assume in what follows.

(i) Adaptive expectations and the optimal policy rule

To examine this we consider the following stylised model. We assume that the central bank minimises Eq. (2.5) subject to

$$y_t = y^\star + \alpha\left(\pi_t - \pi_t^e\right) + \varepsilon_{t,} \tag{4.1}$$

where $y^\star$ is potential output and Eq. (4.1) represents the constraints facing the central bank as before. In addition we assume that expectations of inflation rate are adaptive and are determined by

$$\pi_t^e - \pi_{t-1}^e = a\left(\pi_{t-1} - \pi_{t-1}^e\right), \tag{4.2}$$

where $0 < a < 1$. Using Eq. (4.2) together with Eq. (4.1), we obtain the first-order condition from Eq. (2.5) with respect to π_t:

$$\begin{aligned} \pi_t &= \pi_t^T - \left(\frac{\alpha\lambda}{1+\alpha^2\lambda}\right)\varepsilon_t, \qquad (4.3) \\ \text{where } \pi_t^T &= \left(\frac{1}{1+\alpha^2\lambda}\right)\pi^\star + \left(\frac{a\alpha^2\lambda}{1+\alpha^2\lambda}\right)\sum_{i=0}^{\infty}\left(1-a\right)^i \pi_{t-1-i} \end{aligned}$$

Note that the interim target is calculated as a weighted average of the long-run target and the inherited rate of inflation. The latter is simply taken to be a backward-looking moving average of actual inflation. Note that adaptive expectations does introduce an interim target and so goes part of the way to the opportunistic model. However, it does not rationalise an asymmetric response to shocks which is an important element in the model. What this suggests is that it is necessary to entertain alternatives to the linear-quadratic paradigm in order to rationalise opportunism.

(ii) Nonlinearity of the Phillips curve

(a) The finite horizon case

In this section we assume that the Phillips curve is linear but the effect of the shock itself on the position of the trade-off is nonlinear. We use this formulation as a tractable representation of nonlinearity in the Phillips curve.

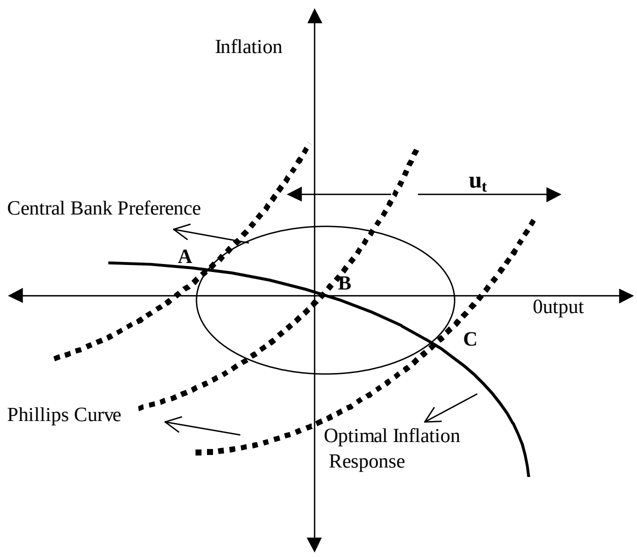

Figure 2: **Optimal inflation response when the Phillips curve is nonlinear**

Figure 2 plots the optimal inflation response when the Phillips curve is nonlinear and the effect of the shock 'u_t' on the position of the trade-off is nonlinear.[11] The

[11]This later assumption is crucial for obtaining a concave inflation response in Figure 2. The Phillips curve in Figure 2 is given by $\pi_t = \alpha\left(e^{\beta y_t - u_t} - 1\right)$. The objective function is a quadratic in both π_t and y_t. If the shock to the Phillips curve is linear i.e., $\pi_t = \alpha\left(e^{\beta y_t} - 1\right) + u_t$, this makes

concentric ellipse in Figure 2 is the central bank's indifference curve, with 'B' denoting the 'bliss point'. The tangency points of the central bank's indifference curve with the Phillips curve trace out an inflation response of just the asymmetric sort we seek; of course it can only be done numerically. A nonlinear Phillips curve with quadratic central bank preferences does not yield a closed-form solution for inflation and must be evaluated numerically- see Orphanides and Wieland (2000). However it can be shown numerically that the optimal reaction function will be nonlinear, with the approximate form: $\pi_t = \pi^\star - a\left(e^{\gamma u_t} - 1\right)$. This closed form solution is obtained from the assumption we now make.

To examine the implication of this modification we propose the following functional form for the Phillips curve:

$$y_t = y^\star + \alpha\left(\pi_t - \pi_t^e\right) + \left(e^{b u_t} - 1\right), \tag{4.4}$$

where α and b are positive constants and u_t is a conditionally normal error with mean zero and variance σ_u^2. In Eq. (4.4) output is assumed to respond asymmetrically to supply disturbances. In addition we assume that expectations of inflation rate are adaptive and are determined by Eq. (4.2) i.e.,

$$\pi_t^e = \frac{aL\pi_t}{1-(1-a)L} = \frac{a\pi_{t-1}}{1-(1-a)L}, \tag{4.5}$$

where L is the lag operator. The policymaker's preference is given by the period

the optimal reaction convex.

loss function

$$L_t = \frac{1}{2}\left[(\pi_t - \pi^\star)^2 + \lambda\,(y_t - y^\star)^2\right] + \tau\,(\pi_t - \pi^\star) \tag{4.6}$$

where $\lambda > 0$ is the relative weight on output-gap stabilization and 'τ' is the constant parameter of a Walsh (1995) inflation contract which is designed to eliminate the bias that comes from the inability to commit under adaptive expectations. Using Eq. (4.4) we obtain the first-order conditions from Eq. (4.6) with respect to π_t:

$$\pi_t\left(1 + \alpha^2\lambda\right) = \pi^\star + \alpha^2\lambda\pi_t^e - \alpha\lambda\left(e^{bu_t} - 1\right) - \tau \tag{4.7}$$

Eq. (4.7) defines the first order condition for the optimal policy rule for inflation under discretion. Substituting Eq.(4.5) for π_t^e in Eq.(4.7) yields:

$$\pi_t = \frac{\pi^\star}{1+\alpha^2\lambda} + \frac{a\alpha^2\lambda}{(1+\alpha^2\lambda)\,(1-(1-a)L)}\pi_{t-1} - \frac{\alpha\lambda\left(e^{bu_t}-1\right)}{1+\alpha^2\lambda} - \frac{\tau}{1+\alpha^2\lambda} \tag{4.8}$$

By continuous backward substitution we have;

$$\pi_t = \pi^\star - \tau - \left(\frac{\alpha\lambda}{1+\alpha^2\lambda}\right)\sum_{i=0}^{\infty}\left(\frac{a\alpha^2\lambda}{(1+\alpha^2\lambda)\,(1-(1-a)L)}\right)^i\left(e^{bu_{t-i}}-1\right) \tag{4.9}$$

where Eq. (4.9) (which is similar to Eq. (3.2)) defines the optimal inflation response when the effect of the shock on the position of the Phillips curve trade-off is nonlinear.[12]

(b) The infinite horizon case

[12] From Eq. (4.9) we observe that to remove the inflation bias through using Walsh contract $\tau = \alpha\lambda\left(1 - e^{\frac{b^2\sigma_u^2}{2}}\right)$.

Suppose we add persistence to the Phillips curve Eq. (4.4) above i.e.,

$$y_t = \rho y_{t-1} + \alpha\left(\pi_t - \pi_t^e\right) + \left(e^{bu_t} - 1\right), \tag{5}$$

and assume that expectations are adaptive as in Eq. (4.5) then the problem in Eq. (4.6) is a dynamic programming problem with one state variable, y_{t-1}, and one control variables, π_t. Thus, the decision problem of the central bank can be expressed as

$$V\left(y_{t-1}\right) = E_{t-1}\min_{\pi_t}\left\{\begin{array}{c}\frac{1}{2}\left[\left(\pi_t - \pi^\star\right)^2 + \lambda\left(y_t - y^\star\right)^2\right] \\ +\left(\tau_0 + \tau_1 y_{t-1}\right)\left(\pi_t - \pi^\star\right) + \beta V\left(y_t\right)\end{array}\right\}, \tag{5.1}$$

where the minimization in period t is subject to Eqs. (4.5) and (5) and τ_0 and τ_1 are constants designed to eliminate the state-dependent inflation bias (see Svensson (1997)). Because of the inability to commit under adaptive expectations the central bank in this case does not internalise the effect of its decisions on inflation expectations. The indirect loss function for this problem is the same as Eq. (2.7) above. The first-order condition from Eq. (5.1) with respect to π_t, yields:

$$\pi_t = \pi^\star - \lambda\alpha\left(y_t - y^\star\right) - \alpha\beta\left[\gamma_1 + \gamma_2\left(y_t - y^\star\right)\right] - \left(\tau_0 + \tau_1 y_{t-1}\right) \tag{5.2}$$

Substituting Eq. (4.5) for π_t^e and Eq. (5) for y_t in Eq. (5.2) yields;

$$\begin{aligned}\pi_t \;=\; & \frac{\pi^\star}{1+\alpha^2\left(\beta\gamma_2+\lambda\right)} - \frac{\alpha\left(\beta\gamma_2+\lambda\right)}{1+\alpha^2\left(\beta\gamma_2+\lambda\right)}\left(\rho y_{t-1} + \left(e^{bu_t}-1\right)\right) \\ & + \frac{\alpha\left(\beta\gamma_2+\lambda\right)y^\star - \beta\gamma_1\alpha}{1+\alpha^2\left(\beta\gamma_2+\lambda\right)} + k\pi_{t-1} - \frac{\left(\tau_0+\tau_1 y_{t-1}\right)}{1+\alpha^2\left(\beta\gamma_2+\lambda\right)}\end{aligned} \tag{5.3}$$

where $k = \left(\frac{a}{1-(1-a)L}\right)\left(\frac{\alpha^2(\beta\gamma_2+\lambda)}{1+\alpha^2(\beta\gamma_2+\lambda)}\right)$. By continuous backward substitution we have:

$$\begin{aligned}\pi_t &= \pi^\star + \alpha\left(\beta\gamma_2+\lambda\right)y^\star - \beta\gamma_1\alpha - \left(\tau_0 + \frac{\tau_1\sum_{i=0}^{\infty}k^i y_{t-1-i}}{1+\alpha^2\left(\beta\gamma_2+\lambda\right)}\right) \\ &\quad - \left(\frac{\alpha\left(\beta\gamma_2+\lambda\right)}{1+\alpha^2\left(\beta\gamma_2+\lambda\right)}\right)\left(\rho\sum_{i=0}^{\infty}k^i y_{t-1-i} + \sum_{i=0}^{\infty}k^i\left(e^{bu_{t-i}}-1\right)\right)\end{aligned} \tag{5.4}$$

where the $\gamma_i^{\prime}s$ can be derived by making use of the Envelope theorem. Eq. (5.4) is the optimal feedback rule for inflation under discretion when the effect of the shock on the position of the Phillips curve trade-off is nonlinear. Following Svensson (1997) the state-dependent inflation bias in Eq. (5.4) can be removed by choosing appropriate values for the $\tau_i^{\prime}s$. What we have discovered is that our proxy for the nonlinearity of the Phillips curve, a nonlinear effect of the shock on the position of the Phillips curve trade-off, yields along with adaptive expectations an optimally opportunistic inflation response.

How strong is the justification for these assumptions? First, the assumption of adaptive expectations is presumably to be justified as an approximation to rational learning (Benjamin Friedman, 1979). Nevertheless, it is not clear why learning should take this form during an episode of inflation stabilisation when inflation is already moderate and policymakers have credibility (such as one might argue is the case today in most OECD countries).

Secondly, evidence of nonlinearity in the Phillips curve first surfaced in Phillips' original work where he found that inflation was highly unresponsive to high levels of unemployment, notably in the 1930s. However, we would point out that the theoretical and empirical evidence for such nonlinearities are mixed.[13] Furthermore, one also needs that the shock be nonlinear in its shift effect. This nonlinear shift effect implies that supply shocks have larger effects on inflation when negative than when positive. We are aware of no theoretical or empirical basis for this.

In sum, justification of these assumptions is not forthcoming in general, though it might be in particular circumstances. The policymakers cited earlier can possibly be regarded as having been convinced that such circumstances prevailed. We may note the parallel with the case for gradualism in curbing inflation advanced by Milton Friedman (1968); in effect he was suggesting that rises in inflation be prevented and that small cuts in money supply growth be made in an overlapping manner, so that just as the former one was moving into the phase of cyclical recovery the successor cut should be made. However, Friedman was arguing for this in the context of a large ("double-digit") inherited inflation rate, a different context from that of the current debate. The arguments for opportunism in the current and recent context of rather low inflation are therefore frankly puzzling.

IV **Conclusion**

The success of monetary policy in restoring price stability in developed economies

[13] Gordon (1997) for instance, maintains that in the US the Phillips curve is linear while Laxton et al. (1999) have presented evidence suggesting a convex shape.

has shifted attention in recent years to the design of monetary policy in a low inflation environment. One result of this shift has been the view that by clearly communicating a low inflation objective, monetary authorities can anchor inflationary expectations, thereby reducing the cost of disinflation. However some recent arguments have favoured an 'opportunistic approach' to disinflation, under which the authorities only reduce inflation when there is a positive supply shock. We examined such an asymmetric policy response within a conventional linear-quadratic framework under rational expectations- such asymmetries, we found unsurprisingly, only result in higher inflation variability under commitment.

We went on to suggest why a policymaker could nevertheless pursue such policies believing them to be optimal. We showed that adaptive expectations combined with nonlinearity in the Phillips curve and the effect of the shock together provide an optimising justification for an opportunistic response. This latterday case for 'asymmetric gradualism' thus requires circumstances where learning, nonlinearity, and asymmetric shift effects are present. These circumstances are possible but appear unlikely in the current low-inflation context of most OECD countries, including the US where opportunism has been most widely discussed.

Appendix

Computation of Inflation Variance

$E\left(\pi_t-\pi^\star\right)^2=E\left(E_{t-1}\pi_t+b\varepsilon_t-\pi^\star\right)^2$

$=E\left(-\delta\sum_{i=0}^{\infty}\left(1-\phi\right)^i e^{\gamma\varepsilon_{t-1-i}}+\frac{\delta}{\phi}e^{\frac{\gamma^2\sigma_\varepsilon^2}{2}}+b\varepsilon_t\right)^2$

$$=\left(\begin{array}{c} \delta^2\sum_{i=0}^{\infty}\left(1-\phi\right)^{2i}E\left(e^{2\gamma\varepsilon_{t-1-i}}\right)+\left(\frac{\delta}{\phi}\right)^2E\left(e^{\gamma^2\sigma_\varepsilon^2}\right)+b^2E\left(\varepsilon_t^2\right) \\ -2\delta\sum_{i=0}^{\infty}\left(1-\phi\right)^iE\left(e^{\gamma\varepsilon_{t-1-i}}.\frac{\delta}{\phi}e^{\frac{\gamma^2\sigma_\varepsilon^2}{2}}\right) \\ -2\delta\sum_{i=0}^{\infty}\left(1-\phi\right)^iE\left(e^{\gamma\varepsilon_{t-1-i}}.b\varepsilon_t\right)+2\frac{\delta}{\phi}E\left(e^{\frac{\gamma^2\sigma_\varepsilon^2}{2}}.b\varepsilon_t\right) \end{array}\right)$$

Taking expectations yields:

$\delta^2E\sum_{i=0}^{\infty}\left(1-\phi\right)^{2i}e^{2\gamma\varepsilon_{t-1-i}}=\frac{\delta^2}{-\phi^2+2\phi}.e^{2\gamma^2\sigma_\varepsilon^2}$

and $-2\delta E\sum_{i=0}^{\infty}\left(1-\phi\right)^ie^{\gamma\varepsilon_{t-1-i}}.\frac{\delta}{\phi}e^{\frac{\gamma^2\sigma_\varepsilon^2}{2}}=-2\left(\frac{\delta}{\phi}\right)^2e^{\gamma^2\sigma_\varepsilon^2}$.

Thus we can express the variance as

$E\left(\pi_t-\pi^\star\right)^2=\left(\frac{\delta^2}{\phi(2-\phi)}\right).e^{2\gamma^2\sigma_\varepsilon^2}+\left(\frac{\delta}{\phi}\right)^2e^{\gamma^2\sigma_\varepsilon^2}+b^2\sigma_\varepsilon^2-2\left(\frac{\delta}{\phi}\right)^2e^{\gamma^2\sigma_\varepsilon^2}$

After simplifying this expression we have

$E\left(\pi_t-\pi^\star\right)^2=\delta^2e^{\gamma^2\sigma_\varepsilon^2}\left(\frac{\phi e^{\gamma^2\sigma_\varepsilon^2}-(2-\phi)}{\phi^2(2-\phi)}\right)+b^2\sigma_\varepsilon^2$

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