Board of Governors of the Federal Reserve System

International Finance Discussion Papers

Number 885

November 2006

Of Nutters and Doves

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November 29, 2006

Abstract

We argue that there are conditions such that any inflation targeting regime is preferable to full policy discretion, even if long-run inflation rates are identical across regimes. The key observation is that strict inflation targeting outperforms the discretionary policy response to sufficiently persistent shocks. Under full policy discretion, inflation expectations over the medium term respond to the shock and thereby amplify its impact on output. As a result, little output stabilization is achieved at the cost of large and persistent inflation fluctuations.

Keywords: Monetary policy, inflation targeting, rules versus discretion

JEL classifications: E52, E58

*Preliminary and Incomplete. The authors are grateful for conversations with Gauti Eggertsson, Mark Gertler, Rick Mishkin, and Andrea Tambalotti; as well as participants in workshops at the Federal Reserve Bank of New York and the Federal Reserve Board. The views expressed in this paper are solely the responsibility of the authors and should not be interpreted as reflecting the views of the Board of Governors of the Federal Reserve System or any other person associated with the Federal Reserve System, or the Federal Reserve Bank of New York.

1 Introduction

Is inflation targeting appropriate for the U.S.? A large body of theory finds that some form or another of inflation targeting approximates optimal monetary policy well. On the other hand, there is little empirical evidence that inflation targeting would improve U.S. monetary policy.[1] Lots of theory but few facts will always leave policymakers skeptical about inflation targeting.[2] Indeed, many have urged to treat the normative implications of misspecified models with caution. It is pointed out that the optimal policy, and hence the proper design of an inflation target, is function of every feature of the model. Uncertainty about parameters, about the state of the economy or even about how to communicate policy leave us with no guarantee that inflation targeting will improve upon the status quo.

We argue that there are conditions such that any inflation targeting regime, even if it is overly strict on inflation, is preferable to full policy discretion. Our result has nothing to do with long-term inflation rates. If the underlying shocks are persistent enough, zero flexibility outperforms policy discretion *in stabilizing the economy*. Other than persistence, the determinants of the optimal monetary policy are irrelevant for the result. We can be uncertain about the optimal inflation targeting regime yet be confident that inflation targeting will improve upon policy discretion.

In a simple, standard New Keynesian model we evaluate the monetary policy response under two scenarios: full policy discretion and strict inflation targeting. In both scenarios the central bank lacks the ability to commit to future policy decisions and takes inflation expectations as given. What distinguishes the two scenarios are the policymaker's objectives. Under full policy discretion, the policymaker weighs output and inflation volatility exactly as society does—we call this policymaker the "dove." In the second scenario the policymaker is totally oblivious to output variation—an "inflation nutter," in the wording of King (1997).

Say there is a persistent cost-push shock, putting downward pressure on the output gap for the current and future periods. Under full policy discretion, the private sector adjusts its medium-term inflation expectations upwards: it correctly anticipates that the dove will allow inflation to rise in order to counter the expected output decline. The independent dynamics of inflation expectations amplify the initial shock. The policy response barely offsets the negative impact of inflation expectations. The more persistent the shocks are, the lesser output stabilization is achieved and the increase in inflation is larger and longer-lasting. Eventually it would have been better to keep inflation flat and let output bear all the adjustment—the inflation nutter's policy. We refer the resulting policy response as

[1] Bernanke and Woodford (2005) contains an excellent collection of papers on inflation targeting, both from the normative and positive perspective.

[2] Perhaps most famously, the former chairman of the Federal Reserve, Alan Greenspan, for whom *"...rules are best viewed only as helpful adjuncts to policy"* (Opening remarks at the Jackson Hole symposium, 2003).

"perverse."

What do we learn, though, from considering an "extreme" form of inflation targeting? We know, at least since Svensson (1997), that the optimal design of inflation targeting involves some flexibility. There is no case for the inflation nutter as the optimal inflation targeter. However, if strict inflation targeting outperforms full policy discretion, then any inflation targeting regime will be preferable to full policy discretion. This is the kind of reassurance policymakers are after.

We emphasize that the perverse policy phenomenon essentially comes down to the persistence of the underlying shocks. Key determinants of the optimal monetary policy, like the weight on output variation in the social welfare function or the slope of the Phillips curve, play little or no role when shocks are persistent enough. How much persistence is needed is, by itself, not very sensitive to different structural parametrizations. There is a simple economic argument behind this claim: whenever inflation is effective at stabilizing output, which helps the case for policy discretion, it generates large price dispersion—which hurts the case for policy discretion.

In order to draw any inference from inflation persistence in the data, it is necessary to distinguish between intrinsic and extrinsic sources of persistence.[3] Only the latter one is relevant for our results. Hence, the likelihood of a perverse policy phenomenon hinges crucially on whether we attribute the high persistence of U.S. inflation to intrinsic or extrinsic factors.

Our findings here are related to the literature on the stabilization bias.[4] It has been pointed out that it is necessary to commit to a history dependent rule in order to implement the optimal policy response, even for i.i.d. shocks. However, to the best of our knowledge, this paper is the first to point out that flexibility can lead to welfare-reducing stabilization policy, strengthening the case for inflation targeting.[5]

Researchers have long sought simple policy rules that perform reasonably well across alternative models. Schmitt-Grohe and Uribe (forthcoming) and Schmitt-Grohe and Uribe (2006) argue that robust policy should not be very sensitive to output fluctuations. Levin and Williams (2003) argue that robust rules exist only when output deviations are important for monetary objectives. Rudebusch (2001) shows how model and parameter uncertainty can rationalize Taylor rules estimated with U.S. data. In the context of inflation targeting design,

[3] In short, intrinsic inflation persistence arises from backward-looking price setting, while extrinsic persistence is the result of persistent fluctuations in the underlying fundamentals. See Section 5 for an extended discussion and references.

[4] Among the early work on the stabilization bias are Jonsson (1997), Svensson (1997), and Clarida, Gali and Gertler (1999).

[5] Armenter and Bodenstein (2005) points out that terms-of-trade shocks lead to the perverse policy responses, so a commitment to a fixed exchange rate can be desirable even if inflation rates are low.

see Giannoni and Woodford (2005), Svensson and Williams (2005), Orphanides and Williams (2006) and Giannoni (2006).

The paper is organized as follows. In the next section we discuss our main result in a simple economy. In Section 3 we seek to understand the determinants of the perverse policy phenomenon. Section 4 derives the optimal degree of flexibility in a simple class of inflation targeting regimes to put our results in the context of robust inflation targeting design. Section 5 takes on the distinction between intrinsic and extrinsic inflation persistence. And then we conclude.

2 The Perverse Policy Phenomenon

We use a simple New Keynesian model to illustrate our argument. The period social welfare loss function is given by

$$l\left(\pi_t, x_t\right) = \left(\pi_t - \pi^*\right)^2 + \lambda\left(x_t - x^*\right)^2 \tag{1}$$

where x^* and π^* are the optimal levels of output and inflation respectively. The parameter $\lambda > 0$ is the society's weight on variation in output versus inflation. A social welfare loss function like (1) can be derived from a structural model, as extensively discussed in Woodford (2003). We offer a preliminary exploration of our results in such a structural model in Section 3.2.

We consider only economies such that the long run output and inflation rates are optimal. Hence all welfare differences arise from the policy response to shocks. In the parlance of Barro and Gordon (1983), there is no inflationary bias in any of the scenarios considered in this section. Since the optimal and long run levels are equal, we can set $x^* = 0$ and $\pi^* = 0$ and interpret x_t and π_t as percentage deviations from their respective long run levels. The social welfare loss function (1) becomes

$$l\left(\pi_t, x_t\right) = \pi_t^2 + \lambda x_t^2. \tag{2}$$

Total welfare loss at date t is given by

$$L_t = E_t\left\{\sum_{j=0}^{\infty} \beta^j\left(\pi_{t+j}^2 + \lambda x_{t+j}^2\right)\right\}$$

where $0 < \beta < 1$ is the intertemporal discount rate and E_t is the expectation operator conditional on information available at date t.

The relationship between inflation and the output gap is given by a New Keynesian Phillips curve,

$$\pi_t = \kappa x_t + \beta E_t \{\pi_{t+1}\} + u_t, \tag{3}$$

where $\kappa > 0$. The exogenous shock u_t introduces a trade-off between inflation and output volatility. We assume the shock follows an autoregressive process

$$u_t = \rho u_{t-1} + \varepsilon_t \tag{4}$$

where $\rho < 1$ and ε_t is *iid* with zero mean.

All that remains is a description of monetary policy. For simplicity the policy instrument is assumed to be the inflation rate. More importantly, the central bank cannot commit to any plan of future policy decisions. In other words, at date t the central bank sets the inflation rate π_t but has no direct control over inflation rates on future dates $t+1, t+2$... The key implication of operating without commitment is that private sector inflation expectations are beyond the control of the central bank.

Within this framework we analyze two different scenarios for monetary policy: full policy discretion and strict inflation targeting. The two scenarios differ on how the policymaker weighs the output gap in his objectives. Let

$$z\left(\pi_t, x_t; \tilde{\lambda}\right) = \pi_t^2 + \tilde{\lambda} x_t^2,$$

denote the period objective function of the policymaker where $\tilde{\lambda} \geq 0$.[6] The full policy discretion scenario is characterized by the dove, who weighs the output gap exactly as society does, $\tilde{\lambda} = \lambda$. The strict inflation targeting scenario has an inflation nutter, $\tilde{\lambda} = 0$, in command of the central bank.

We emphasize that each scenario features a different central banker operating the same central bank. In particular, both policymakers operate with the same policy instrument (inflation) under lack of commitment.

2.1 Full Policy Discretion: The Dove

In our first scenario monetary policy is set by a central bank that weighs output and inflation variation exactly as society does. The policymaker in place, whom we refer to as the dove,

[6] The objective function is actually given by

$$E_t \sum_{j=0}^{\infty} \beta^j z\left(\pi_{t+j}, x_{t+j}; \tilde{\lambda}\right)$$

but since the central bank cannot commit to future policy decisions, we can focus on the period objective function.

has an objective function given by (2). We index this scenario with a superscript *pd*.

Formally, inflation at date t is given by the solution to

$$\min_{\pi_t, x_t} \pi_t^2 + \lambda x_t^2$$

subject to the Phillips curve (3). Private sector inflation expectations $E_t\{\pi_{t+1}\}$ are taken as given. The first order condition characterizing the solution to the central bank's problem is

$$\pi_t = \frac{\lambda}{\kappa^2 + \lambda}\left(\beta E_t\{\pi_{t+1}\} + u_t\right). \tag{5}$$

We can view (5) as the policy decision that describes how the central bank reacts to the shock and inflation expectations.

Rational expectations dictate that the central bank's future decision is the determinant of private sector inflation expectations. The policy decision (5) at date $t+1$, conditional on the information at date t, is

$$E_t\{\pi_{t+1}\} = \frac{\lambda}{\kappa^2 + \lambda}\left(\beta E_t\{\pi_{t+2}\} + E_t\{u_{t+1}\}\right).$$

The private sector correctly anticipates that output will be off its optimal level at date $t+1$, leading the central bank to let inflation deviate from its long run level as well. Hence the private sector adjusts its inflation expectations to the shock forecast, $E_t\{u_{t+1}\}$. Using the policy decision (5) at dates $t+2, t+3...$ we determine $E_t\{\pi_{t+2}\}$, $E_t\{\pi_{t+3}\}$ ... and then solve for $E_t\{\pi_{t+1}\}$

$$\begin{aligned} E_t\{\pi_{t+1}\} &= \frac{\lambda}{\kappa^2 + \lambda} E_t\{u_{t+1}\} + \left(\frac{\lambda}{\kappa^2 + \lambda}\right)^2 \beta E_t\{u_{t+2}\} + ... \\ &= \frac{\lambda}{\kappa^2 + \lambda} \sum_{j=0}^{\infty} \left(\frac{\beta\lambda}{\kappa^2 + \lambda}\right)^j E_t\{u_{t+1+j}\}. \end{aligned}$$

It is then the whole expected path $\{E_t u_{t+j}\}_{j=1}^{\infty}$ which determines inflation expectations at date t. The shock follows the autoregressive process (4), so $E_t\{u_{t+j}\} = \rho^j u_t$ and the private sector inflation expectations at date t are

$$E_t\{\pi_{t+1}\} = \frac{\lambda}{\kappa^2 + \lambda(1 - \beta\rho)} \rho u_t. \tag{6}$$

It is not hard to see that the j-steps ahead inflation expectation is

$$E_t\{\pi_{t+j}\} = \frac{\lambda}{\kappa^2 + \lambda(1 - \beta\rho)} \rho^j u_t.$$

Hence a persistent shock $\rho > 0$ induces inflation expectations to deviate for the medium term. Long-term expectations remain well anchored as the shock eventually fades. The solution (6) also makes clear inflation expectations *comove* with the shock as long as it is persistent, $\rho > 0$. We shall return to this: the response of the inflation expectations is at the core of the failure of the dove to conduct proper stabilization policy.

The policy decision (5) determines the inflation response once we substitute for the inflation expectations $E_t \{\pi_{t+1}\}$,

$$\pi_t^{pd} = \frac{\lambda}{\kappa^2 + \lambda (1 - \beta\rho)} u_t. \tag{7}$$

Inflation is proportional to the shock and therefore inherits its statistical properties. In particular, inflation will be as persistent as the shock. This also confirms that the unconditional mean of inflation is zero, $E\pi_t = 0$.

Finally, we use the Phillips curve to solve for the output gap

$$x_t^{pd} = -\frac{\kappa}{\kappa^2 + \lambda (1 - \beta\rho)} u_t \tag{8}$$

and the period welfare loss is given by

$$l_t^{pd} = \left[\left(\frac{\lambda}{\kappa^2 + \lambda (1 - \beta\rho)} \right)^2 + \lambda \left(\frac{\kappa}{\kappa^2 + \lambda (1 - \beta\rho)} \right)^2 \right] u_t^2. \tag{9}$$

2.2 Strict Inflation Targeting: The Inflation Nutter

The second scenario features an inflation nutter in charge of the central bank. The inflation nutter seeks to minimize inflation variation without any regard for output variation. This has also been called strict or pure inflation targeting in the literature. We index this scenario with the superscript it.

The central bank's problem is trivial, as it chooses to implement zero inflation at all periods, $\pi_t^{it} = 0$ for all $t \geq 0$. Private sector inflation expectations follow, $E_t \{\pi_{t+1}\} = 0$. The Phillips curve (3) implies that the output gap is

$$x_t^{it} = -\frac{1}{\kappa} u_t. \tag{10}$$

The welfare period loss is trivially given by

$$l_t^{it} = \lambda \frac{1}{\kappa^2} u_t^2. \tag{11}$$

2.3 Welfare Comparison

The dynamics of inflation and output across the two scenarios are very much as one would expect. Consider a shock $u_t > 0$ which puts downward pressure on output. Inflation under policy discretion raises, while it stays flat under strict inflation targeting

$$\pi_t^{pd} = \frac{\lambda}{\kappa^2 + \lambda(1-\beta\rho)} u_t > 0 = \pi_t^{it}.$$

We have already discussed that inflation under policy discretion is as persistent as the shock. The rise in inflation has a stabilizing effect on output that is absent under the inflation nutter. Combining (8) and (10), we have that

$$\frac{x_t^{pd}}{x_t^{it}} = \frac{\kappa^2}{\kappa^2 + \lambda(1-\beta\rho)} < 1$$

so output gap deviations are smaller under full policy discretion. The inflation nutter, by being oblivious to everything but inflation, induces excessive output variation. The dove instead trades off some price dispersion for a smoother output response. It would seem like the dove's decision to do so indicates that stabilization policy under full policy discretion will be unambiguously better. Not so fast.

Note how the dynamics change as the persistence of the shock increases. For the same realization of the shock, inflation under policy discretion rises by more and for longer. Yet less output stabilization is achieved. This certainly does not help the case for full policy discretion! As we take persistence to its upper bound, $\rho \to 1$, and take the intertemporal discount rate to be approximately 1, we have that $\beta\rho \to 1$ and the resulting dynamics are

$$\begin{aligned} \pi_t^{pd} &= \frac{\lambda}{\kappa^2} u_t > \pi_t^{it} = 0 \\ x_t^{pd} &= x_t^{it}. \end{aligned}$$

The policy response is, in absolute terms, welfare reducing: inflation rises yet output displays no moderation. This is what we call the perverse policy response phenomenon. Clearly, the period social welfare is strictly lower under full policy discretion than under strict inflation targeting,

$$l_t^{pd} = \left(\frac{\lambda}{\kappa^2} + 1\right) \frac{\lambda}{\kappa^2} u_t^2 > \frac{\lambda}{\kappa^2} u_t^2 = l_t^{it},$$

as seen by evaluating (9) and (11).[7] By continuity it is clear that there exists $\rho < 1$ such that the inflation nutter outperforms the dove. Note that this holds for any shock u_t and for all values of λ and κ.

[7] Note the period welfare loss function is well defined for the limiting case $\beta\rho \to 1$.

In short, for sufficiently persistent shocks, zero flexibility is preferred to discretion. We have shown this in what seemed to be the ideal scenario for policy discretion: without differences in long run inflation and in the aftermath of a shock. Instead of a sound stabilization policy, we find the dove engineering a large, persistent, costly, and futile rise in inflation.

The independent response of inflation expectations under policy discretion is behind this result. As discussed above, under full policy discretion inflation expectations comove with the shock over the medium term,

$$E_t\left\{\pi_{t+1}\right\} = \frac{\lambda\rho}{\kappa^2 + \lambda\left(1-\beta\rho\right)} u_t.$$

The comovement of inflation expectations amplifies the initial shock. To see how, note the New Keynesian Phillips curve (3) is perceived by the central bank as an "Old" Keynesian Phillips curve since inflation expectations are taken as given,

$$\begin{aligned} \pi_t &= \kappa x_t + \beta E_t\left\{\pi_{t+1}\right\} + u_t, \\ &= \kappa x_t + \left(\frac{\beta\lambda\rho}{\kappa^2 + \lambda\left(1-\beta\rho\right)} + 1\right) u_t. \end{aligned}$$

The more persistent the shock, the larger the amplifying role of inflation expectations. The policy response barely offsets the negative output impact of inflation expectations. This explains why inflation rises but no effective output stabilization is achieved. It would have been better to keep inflation flat and let output bear all the adjustment—the inflation nutter's policy.

At this point it is useful to compare both scenarios with the optimal policy response. We refer the interested reader to Woodford (2003) for a complete analysis of the optimal monetary policy. The optimal policy requires a commitment technology that is not available to the central bank. Hence neither the dove nor the inflation nutter can implement it.

Figure 1 displays the dynamics of inflation and output for the two scenarios as well as for the optimal policy response. The shock has an autocorrelation of .9, which is sufficient to trigger the perverse policy response phenomenon. We document the complete parametrization in Section 3.2.

The upper panel in Figure 1 displays the inflation response. The responses under full policy discretion and strict inflation targeting are the dotted and the solid lines respectively. The optimal policy response is given by the dashed line. Relative to the optimal policy response, inflation under full policy discretion overreacts on impact. Note that under the optimal policy response inflation dies out quite fast—after one year it is very close to its long run level. The rationale behind the optimal policy response is precisely to avoid the feedback from high medium term inflation expectations. In contrast, inflation is quite persistent under full policy discretion.

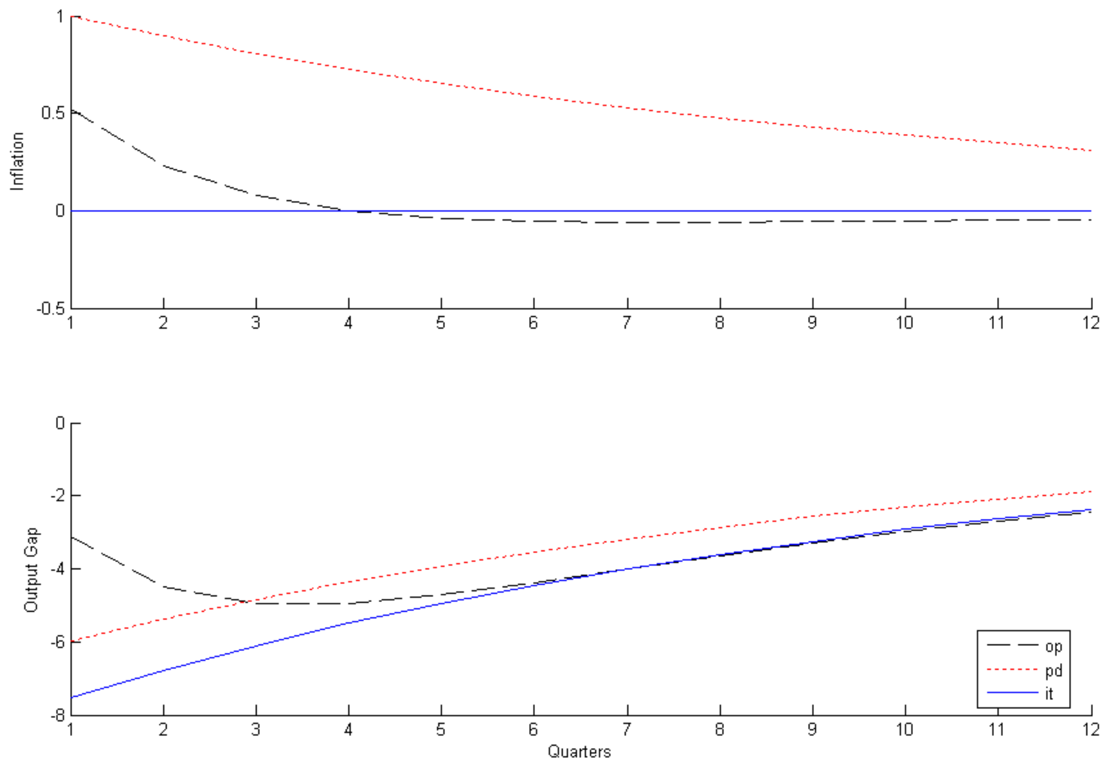

Figure 1: **Inflation and Output Dynamics under each scenario.** See Section 3.2 for details on baseline parameters.

The output gap is displayed in the lower panel of Figure 1. First, we observe that the dove effectively achieves some output smoothing compared to the inflation nutter. The comparison with the optimal monetary policy, though, is illustrative of the perverse effect of inflation expectations. On impact output falls much less under the optimal monetary policy than under full policy discretion—despite the inflation response being much larger in the latter. The optimal policy calls for the output gap to deteriorate in the medium term. Overall, the dove achieves some mild output stabilization in the medium term in exchange for large, persistent inflation and subpar output stabilization in the short term. The inflation nutter, on the other hand, forgoes all the output stabilization on the short term for a flat response of inflation.

3 A Preliminary Exploration

In this section we characterize the threshold of shock persistence such that strict inflation targeting outperforms full policy discretion. The aim is instead to understand its determinants.

3.1 The Persistence Threshold

The welfare period losses under full policy discretion and strict inflation targeting, (9) and (11), can be written as functions of the shock and reduced form parameters, $l_t^{pd}(u_t; \lambda, \kappa, \rho)$ and $l_t^{it}(u_t; \lambda, \kappa)$, respectively. We obviate the dependence with respect to the intertemporal discount rate β. As discussed above, the period welfare loss under full policy discretion is strictly increasing in the persistence of the shock, ρ. We can characterize the welfare ranking across scenarios in terms of a persistence threshold. Let $\bar{\rho}(\lambda, \kappa)$ be the solution to

$$l_t^{it}(u_t; \lambda, \kappa) = l_t^{pd}(u_t; \lambda, \kappa, \bar{\rho}(\lambda, \kappa))$$

such that $\beta\rho < 1$. This leads to

$$2\lambda(1 - \beta\bar{\rho}(\lambda, \kappa)) + \left(\frac{\lambda}{\kappa}\right)^2 (1 - \beta\bar{\rho}(\lambda, \kappa))^2 = \lambda \tag{12}$$

which makes clear that the realization of the shock u_t is irrelevant for the threshold.[8] Strict inflation targeting outperforms full policy discretion for all parametrizations $\{\lambda, \kappa, \rho\}$ such that $\rho \geq \bar{\rho}(\lambda, \kappa)$.

[8] Hence the only relevant statistical property of the shock is its persistence—in particular, volatility does not affect the welfare ranking of the two scenarios.

We find that $\bar{\rho}$ is the smallest solution to the quadratic equation (12),

$$\beta\bar{\rho}\left(\lambda,\kappa\right)=1+\frac{\kappa^{2}}{\lambda}-\sqrt{\frac{\kappa^{2}}{\lambda}\left(1+\frac{\kappa^{2}}{\lambda}\right)}. \tag{13}$$

For all $\kappa,\lambda>0$ there exists $\bar{\rho}$ such that $\bar{\rho}\beta<1$.

The persistence threshold $\bar{\rho}\left(\lambda,\kappa\right)$ is increasing in λ and decreasing in κ.[9] Both comparative statics are as one would expect them. For a given level of persistence, the case for full policy discretion is stronger the more society cares about output variation relative to inflation variation, i.e., the higher λ. Hence the persistence threshold increases with λ. Similarly, full discretion performs better if the Phillips curve is flatter, i.e., κ is lower, as inflation is more effective in stabilizing output.

The welfare comparison for the full parameter space $\{\lambda,\kappa,\rho\}$ is displayed in Figure 2. The value for the Phillips curve coefficient, κ, is in the horizontal axis; the output gap weight in the social welfare loss function, λ, is on the vertical axis. The contour lines indicate pairs $\{\lambda,\kappa\}$ which map into a constant persistence threshold $\bar{\rho}$. For parametrizations $\{\lambda,\kappa\}$ to the southeast of a contour line, strict inflation targeting outperforms full policy discretion. Our claim that the perverse policy response arises as long as the shocks are sufficiently persistent is clearly illustrated: the higher the persistence, the larger the parameter subspace where strict inflation targeting dominates.

Note that the contour lines become more steeper for higher values of persistence. This implies that the perverse policy phenomenon becomes quite robust to parametrizations of λ and κ for shocks with a half-life past three quarters.

3.2 A Structural Approach

Equations (2) and (3) can be derived from first principles and parameters can be given a structural interpretation. The reader is referred to Woodford (2003) for details. The basic structure of the economy features a representative household who consumes a variety of goods and a continuum of firms that behave as monopolistic competitors. A nominal friction is introduced a la Calvo: each period a randomly draw fraction α of firms cannot update their nominal price.

The output weight in the period social welfare loss (2) is given by

$$\lambda=\frac{\kappa}{\theta},$$

[9] For comparative statics, it is convenient to rewrite (13) as $\left(\beta\rho-1\right)^{2}/(2\beta\bar{\rho}-1)=\kappa^{2}/\lambda$.

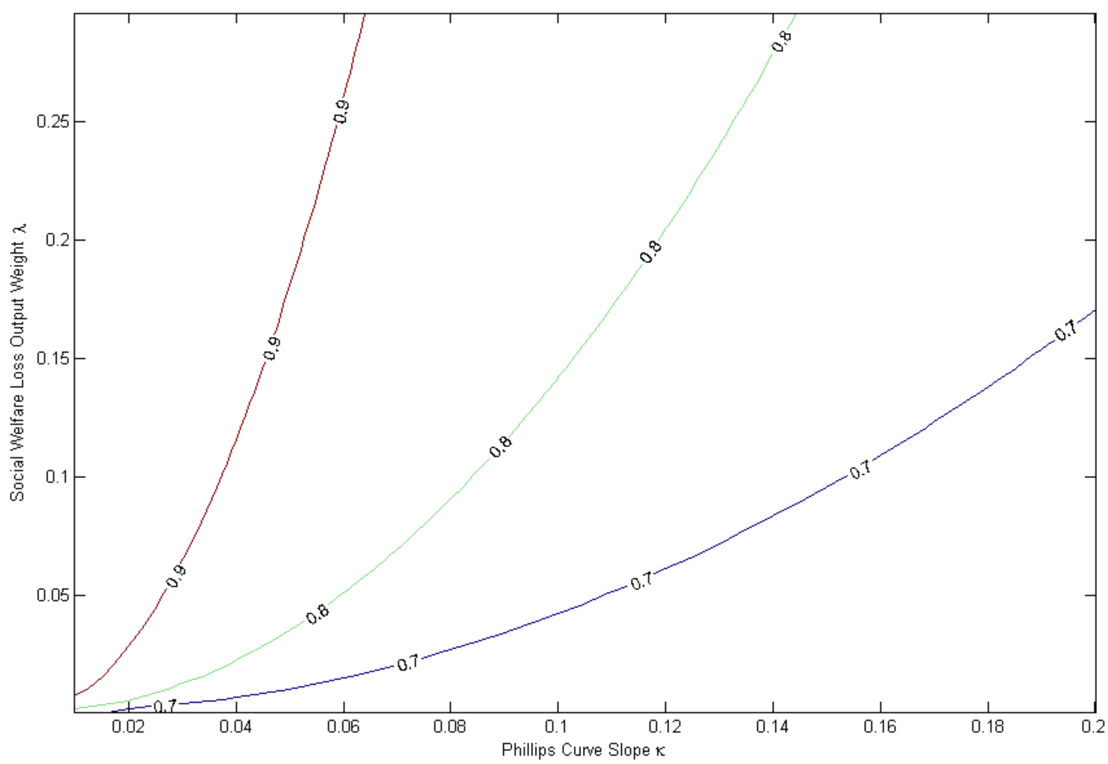

Figure 2: **Welfare Comparison on the full Parameter Space** Each contour line plots the pairs $\{\kappa, \lambda\}$ with a constant persistence threshold.

where θ is the elasticity of substitution across varieties. The slope of the Phillips curve is

$$\kappa = \frac{(1-\alpha)(1-\alpha\beta)}{\alpha}\frac{(\sigma^{-1}+\omega)}{1+\omega\theta},$$

where α is the fraction of firms that do not change the price; σ is the intertemporal elasticity of substitution, and ω is the elasticity of the real marginal cost with respect to own output. The shock u_t induces non-efficient fluctuations in output in order to introduce a trade-off between output and inflation variation. These shocks are often called cost-push shocks.

As discussed above, we are interested in the persistence threshold $\bar{\rho}(\lambda, \kappa)$ such that for $\rho \geq \bar{\rho}(\lambda, \kappa)$ the welfare under strict inflation targeting is higher than under full policy discretion. With the exception of the elasticity of substitution θ, all structural parameters will affect λ and κ equally as the structural model dictates them to be proportional. This is important because, as discussed in the previous subsection, the output weight and the slope of the Phillips curve have opposite effects on the persistence threshold. These countervailing effects imply that the persistence threshold is not very sensitive to different structural parametrizations.

We explore this point further by computing the persistent threshold for different degrees of price stickiness. The remaining parameters are set to the following baseline values. The model is evaluated at a quarterly frequency. The intertemporal discount rate β is set to .995 in order to replicate a 2% annual real interest rate. The elasticity of the real marginal cost with respect to own output is taken from Rotemberg and Woodford (1997), who choose a value close to $\omega = .5$. The elasticity of substitution matches a 20% markup, $\theta = 6$. Finally the intertemporal elasticity of substitution corresponds to log-preferences, $\sigma = 1$.

Figure 3 plots the threshold value, $\bar{\rho}$, as a function of the average duration of a nominal price, $\alpha(1-\alpha)^{-1}$. Most researchers assume an average duration between 3 and 5 quarters. For these values, the persistence threshold is below .8. Even for an average duration over two years the persistence threshold does not rise above .9.

Nominal frictions strengthen, only slightly, the case for full policy discretion. For a high degree of price stickiness, the Phillips curve is basically flat and inflation is very effective at stabilizing output. However, the effect of price stickiness is small. This is perhaps surprising as the slope of the Phillips curve is very sensitive to the level of price stickiness. An increase in the average price duration from two to four quarters cuts the slope to one third. The structural relationship between the slope of the Phillips curve and the output weight in the welfare loss is behind this. When only a limited number of firms can change prices, even small amounts of inflation require large price dispersion. High price stickiness enables the dove to perform more output stabilization but it also implies that the shortcomings of policy discretion (excess inflation) are more costly.

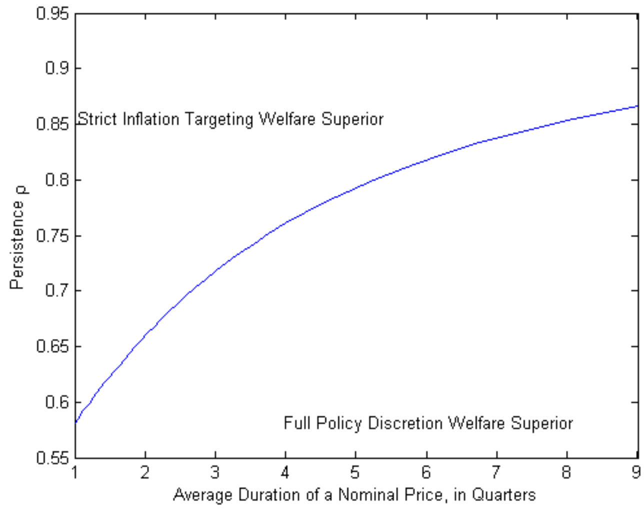

Figure 3: **Persistence Threshold for the Perverse Policy Response** Baseline parameters detailed in the text.

Figure 4 reproduces Figure 2 together with the relationship between λ and κ implied by the baseline calibration for the structural model (dashed line). For any choice of α, the resulting parametrization will lie in the locus given by the dashed line. The positive slope of the relationship $\lambda = \kappa/\theta$ guarantees that the persistence threshold is not very sensitive.

The same logic carries over to the other structural parameters. For example, price setting complementarities have been analyzed extensively in the literature, but they do not break the link between the slope of the Phillips curve and the output weight.[10] We report a comprehensive analysis in Figures 5-7. One at a time we explore different values for the baseline parameters combined with a wide range of choices for the fraction of sticky prices. In each graph, the fraction of sticky prices is on the horizontal axis and the parameter of choice on the vertical axis. Each contour line plots parameter pairs such that the persistence threshold $\bar{\rho}$ is constant. For a given persistence ρ, strict inflation targeting outperforms full policy discretion for parametrizations to the left of the respective contour line.

The general message from Figures 5-7 is that the perverse policy phenomenon is pervasive. A persistence level of .9 virtually assures that strict inflation targeting outperforms full policy discretion for any structural parametrization where the average duration of a nominal price is below two years.

[10] In our simple model, the degree of complementarity is given by $\frac{1+\omega\theta}{\sigma^{-1}+\omega}$.

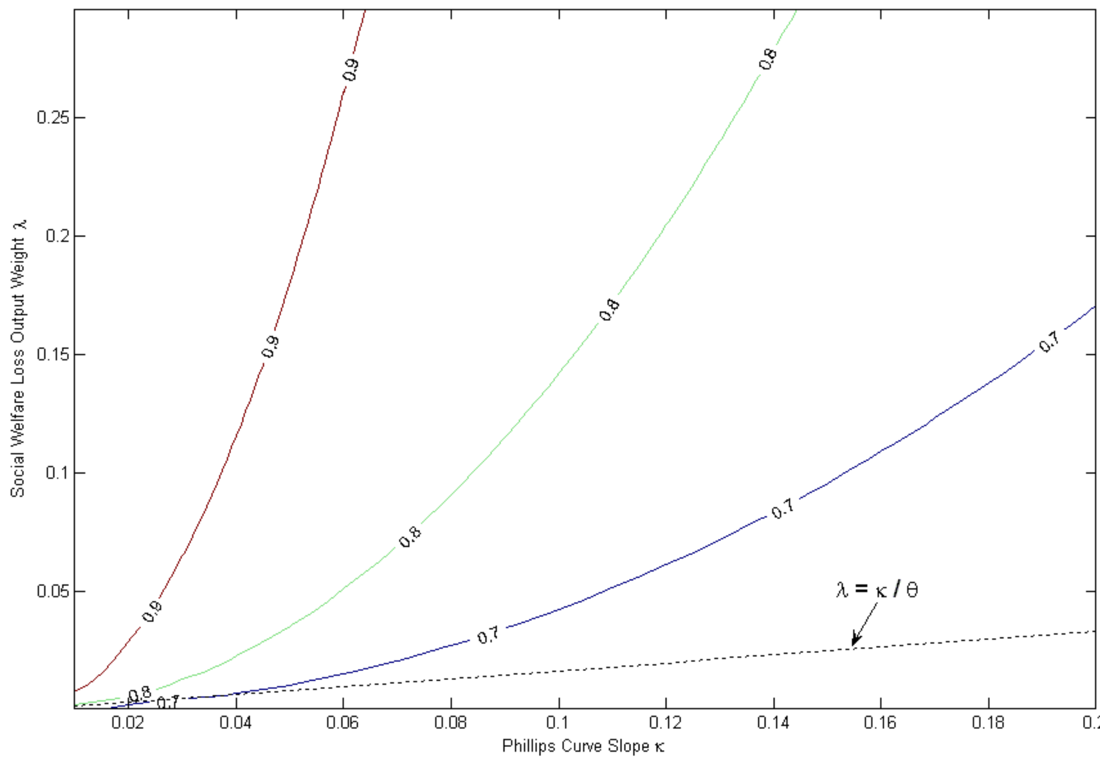

Figure 4: **Welfare Comparison on the full Parameter Space** Each contour line plots the pairs $\{\kappa, \lambda\}$ with a constant persistence threshold. The dashed line indicates the relationship imposed by the structural model.

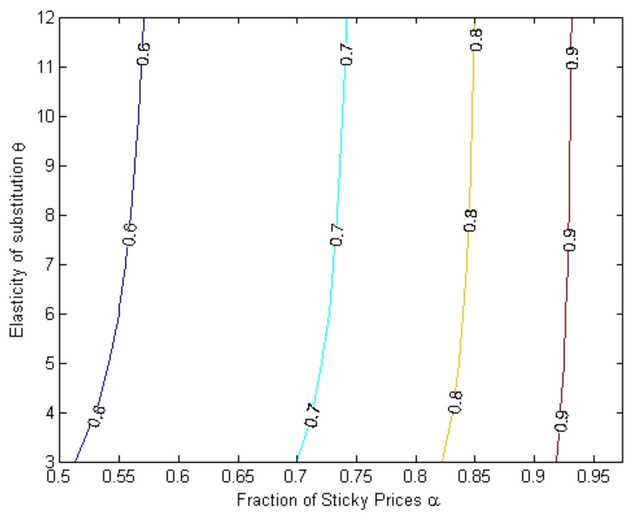

Figure 5: **Robustness: Elasticity of Substitution** Each contour line plots the pairs $\{\alpha, \theta\}$ with a constant persistence threshold. Strict inflation targeting outperforms full policy for parametrizations to the left of the contour line. See text for details on unspecified parameters.

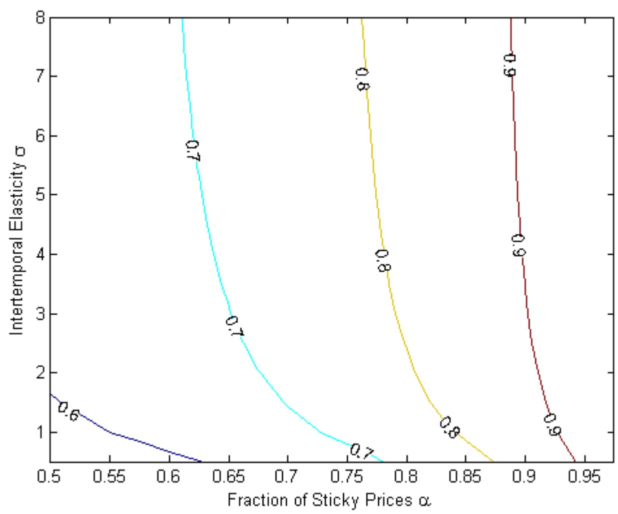

Figure 6: **Robustness Exercises: Intertemporal Elasticity** Each contour line plots the pairs $\{\alpha, \sigma\}$ with a constant persistence threshold. Strict inflation targeting outperforms full policy for parametrizations to the left of the contour line. See text for details on unspecified parameters.

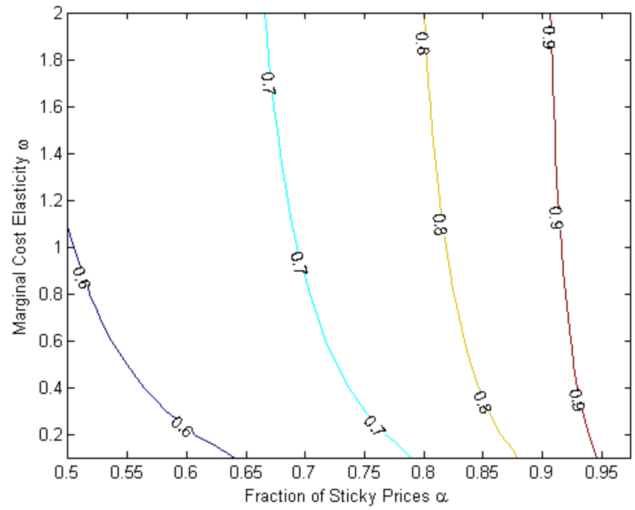

Figure 7: **Robustness Exercises: Marginal Cost Elasticity** Each contour line plots the pairs $\{\alpha, \omega\}$ with a constant persistence threshold. Strict inflation targeting outperforms full policy for parametrizations to theleft of the contour line. See text for details on unspecified parameters.

4 Implications for Inflation Targeting Design

Full policy discretion and strict inflation targeting are just two out of many possible designs of inflation targeting. In this section we study a larger class inflation targeting regimes. As pointed out by Svensson (1997), the optimal level of flexibility in an inflation targeting regime does not correspond to either the inflation nutter or the dove. However, the derivation of the optimal degree of flexibility helps to put our results in context and lay out the implications for *robust* inflation targeting.

Formally, we return to our formulation of the policymaker's objective function,

$$z\left(\pi_t, x_t; \tilde{\lambda}\right) = \pi_t^2 + \tilde{\lambda} x_t^2. \tag{14}$$

We now consider any policymaker with $\tilde{\lambda} \in [0, \lambda]$—this is the class of inflation targeting regimes we focus on. The inflation nutter, $\tilde{\lambda} = 0$, corresponds to zero flexibility; the dove, $\tilde{\lambda} = \lambda$, features no inflation targeting; and any intermediate values $\tilde{\lambda} \in (0, \lambda)$ corresponds to a different degree of flexibility.[11]

We can solve for inflation and output dynamics for an arbitrary $\tilde{\lambda}$ using (3) and (4),

$$\begin{aligned} \pi_t &= \frac{\tilde{\lambda}}{\kappa^2 + \tilde{\lambda}(1-\beta\rho)} u_t, \\ x_t &= -\frac{\kappa}{\kappa^2 + \tilde{\lambda}(1-\beta\rho)} u_t. \end{aligned}$$

The period loss function is then given by

$$l_t\left(\tilde{\lambda}\right) = \left[\left(\frac{\tilde{\lambda}}{\kappa^2 + \tilde{\lambda}(1-\beta\rho)}\right)^2 + \lambda\left(\frac{\kappa}{\kappa^2 + \tilde{\lambda}(1-\beta\rho)}\right)^2\right] u_t^2 \tag{15}$$

defined for $\tilde{\lambda} \geq 0$.

With the "generalized" loss function (15) we can easily compute the optimal degree of flexibility λ^*, that is, the one that minimizes the resulting equilibrium period loss. Taking first order conditions we find that

$$\lambda^* = \lambda(1-\beta\rho). \tag{16}$$

[11] What does link the policymaker's weight on output $\tilde{\lambda}$ to policy flexibility? Most inflation targeting regimes feature a tolerance range. If inflation steps out of the range the central bank is held accountable. Mishkin and Westelius (2005) show how to think of the tolerance range as a penalty function on inflation deviations. The tighter the range, the harsher the central bank's penalty for inflation deviations and the lower the relative weight on output deviations.

Figure 8: **The Optimal Degree of Flexibility in Inflation Targeting** Baseline parameters.

The first thing to note is that the optimal degree of flexibility lies somewhere between strict inflation targeting and full policy discretion, $0 < \lambda^* \leq \lambda$. The inflation nutter is the optimal policymaker only for the limiting case $\beta\rho \to 1$; the dove only when shocks have no persistence $\rho = 0$ or society does not value the future $\beta = 0$.

Figure 8 plots the period welfare loss as a function of the policymaker's weight on the output gap, $\tilde{\lambda}$, as in (14). Parameter values correspond to the baseline calibration, with $\alpha = 2/3$ and $\rho = .9$. We indicate the location of the optimal degree of flexibility λ^* as well as the output weight in the social welfare function (2), λ. Note that $l\,(0) < l\,(\lambda)$, i.e., the inflation nutter ranks above the dove.

The precise level of flexibility as given in (16) is a function of all of the parameters in the economy and there is considerable uncertainty with respect to many of them.[12] Even small deviations of the better "known" parameters can lead to very different optimal levels of flexibility. Moreover, there may be difficulties in computing the optimal gap and communicating the degree of flexibility to the public. Hence there is the concern that a country will be worse off under an incorrectly chosen/communicated inflation targeting framework than under full policy discretion.[13]

[12] Recall that λ is a function of many structural parameters. See section 3.2 for details.

[13] Some of the criticisms of inflation targeting in Fed (2003) emphasized this possibility.

However, in our analysis any inflation targeting regime is better than full policy discretion—even if the targeting regime is more strict than optimal. Coming back to Figure 8, if we establish that $l(0) < l(\lambda)$, then $l\left(\tilde{\lambda}\right) \leq l(\lambda)$ for all $\tilde{\lambda} \in [0, \lambda]$. Uncertainty about the optimal degree of flexibility should not deter policymakers from adopting inflation targeting.

4.1 Fixing the Stabilization Bias

It has been pointed out that commitment is needed to implement the optimal policy response even when policy discretion features no inflationary bias. The difference between the discretionary and the optimal policy responses is known as the stabilization bias. Our analysis shows that the stabilization bias can be strong enough to make flexibility welfare reducing.

Most of the research on the stabilization bias has focused on the conditions needed to implement the optimal monetary policy when the central bank lacks commitment. As Woodford (2003) shows, the optimal policy response is (generically) history-dependent, i.e., it is a function of present *and past* realizations of shocks. Therefore no parametrization $\tilde{\lambda}$ in our characterization of the policymaker's objectives (14) can implement the optimal policy response.

A possibility, put forward by Svensson (2003) and Giannoni and Woodford (2005), is a *targeting rule*. The central bank targets an inflation target which is a function of present and past realizations of the output gap, $\pi^*(x_t, x_{t-1}, ...)$. The targeting rule can always be designed such that the optimal policy response is implemented.

Indeed, some researchers have departed from policymaker's objectives of the functional form (14) to incorporate some history-dependence. A well known proposal is price-level targeting—see Vestin (2003). The central bank objectives are given by deviations of the price level, $p_t^2 + \lambda x_t^2$. The price level is history-dependent in the sense that it reflects the whole history of past inflation rates. Vestin (2003) shows that in a special case the optimal policy is implemented and more generally it can be well approximated. Cecchetti and Kim (2005) go further and consider "hybrid targeting," a combination inflation and price level targeting.

5 Intrinsic and Extrinsic Inflation Persistence

We have shown that persistent shocks map into large and persistent inflation fluctuations under full policy discretion. Strict inflation targeting, and by extension any flexible inflation targeting regime, is then better than full policy discretion.

Inflation is very persistent in the U.S.[14] Before we can draw any inference about the perverse policy phenomenon, it is necessary to distinguish between intrinsic and extrinsic inflation persistence. Intrinsic persistence arises from some backward-looking price-setting mechanism, e.g., price indexation to past realizations of inflation. Extrinsic persistence stems from persistent fluctuations of the underlying determinants of inflation like the output gap.[15]

The simple New Keynesian model we have used all along has only extrinsic inflation persistence in the form of a persistent cost-push shock u_t. We introduce price indexation as a source of intrinsic inflation persistence. The Phillips curve (3) now has a backward-looking term

$$\pi_t = \gamma\pi_{t-1} + \kappa x_t + \beta E_t \{\pi_{t+1} - \gamma\pi_t\} + u_t \tag{17}$$

where $\gamma > 0$ measures the degree of indexation to the most recent available inflation measure. This augmented Phillips curve (17) has a structural foundation—see Woodford (2003) for details. Once we derive (17) from first principles, we find that the associated period social welfare loss function is

$$l_t = (\pi_t - \gamma\pi_{t-1})^2 + \lambda x_t^2. \tag{18}$$

Recall that it is price dispersion, and not inflation per se, that is welfare reducing. Price indexation implies that sticky prices are adjusted according to $\gamma\pi_{t-1}$, so only the difference $\pi_t - \gamma\pi_{t-1}$ generates price dispersion. The dove's objective is now given by (18)—we stick to the assumption that the dove seek to minimize society's welfare loss. Price indexation is irrelevant for the objective of the inflation nutter.

The persistence threshold is independent of the degree of price indexation $\gamma > 0$. The persistence of the shock, i.e., extrinsic inflation persistence, is all that matters for the perverse policy phenomenon. The fastest way to see this result is to rewrite (17) and (18) in terms of $\tilde{\pi}_t = \pi_t - \gamma\pi_{t-1}$. The resulting equations look exactly as (2) and (3), so the welfare results of the previous sections can be applied.

If most of the observed inflation persistence is due to extrinsic factors, the perverse policy response phenomenon is likely and there is a strong case for inflation targeting. We only offer here a couple of observations in favor of extrinsic inflation persistence. First, micro-level price data shows that a large majority of firms keep their price fixed for some time—and price adjustments are not clustered around past inflation realizations. This is not consistent with the price indexation assumption. Second, large-scale macroeconomic models usually work with very persistent shocks—being technology shocks the prime example—and include

[14] While there is a consensus that inflation is persistent, there are hotly debated questions about the nature of the persistence. Is inflation stationary? Has inflation persistence changed? Are there breaks in the inflation mean?

[15] See Angeloni, Aucremanne, Ehrmann, Gali, Levin and Smets (2006) for an overview of the exhaustive research on the topic by the Inflation Persistence Network at the European Central Bank.

further mechanisms for a slow propagation—like adjustment costs. This is a consequence of the slow moving nature of most macroeconomic variables.[16]

6 Conclusions

Optimal monetary policy has been at the core of the debate on inflation targeting. Researchers have been seeking to approximate the optimal policy—ideally across a variety of acceptable models—by some form of inflation targeting. Policymakers, however, often feel uncomfortable about optimal policy analysis given the large uncertainty about the economy's workings.

We argue that there are conditions such that any inflation targeting regime, even if it is overly strict on inflation, is preferable to full policy discretion. A sufficient condition is that the underlying shocks are persistent. Other determinants of optimal monetary policy play little or no role. It is thus possible to be uncertain about the optimal inflation targeting regime yet to be assured that a move towards inflation targeting will improve monetary policy.

Our argument is built upon the fact that zero flexibility outperforms policy discretion in stabilizing the economy in response to a persistent shock. This theoretical point is important by itself. Rules are commonly thought to provide some gains in long-term inflation at the cost of forgone stabilization policy. Our result shows that the loss of stabilization policy can be an advantage of rules.

Of course a serious quantitative analysis is needed before we draw any firm conclusion. Such analysis will face important challenges. First and foremost, there is the question of whether full policy discretion is an appropriate description of current U.S. monetary policy. Second, large-scale monetary models have many sources of shocks: it would be important to evaluate them jointly. Finally, one would need to confidently evaluate the sources of inflation persistence in the data as only extrinsic persistence induces the perverse policy phenomenon. As demanding as it is, such a research agenda has better prospects than chasing a reassuring characterization of the optimal monetary policy.

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