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Price Level Targeting vs. Inflation Targeting: A Free Lunch?

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Abstract

Price level targeting (without base drift) and inflation targeting (with base drift) are compared with persistence in output (generated by sticky prices, for instance). Counter to conventional wisdom, price level targeting results in *lower* short-run inflation variability than inflation targeting (if output is at least moderately persistent). Price level targeting also eliminates any average inflation bias. Even if the preferences of society correspond to inflation targeting, it may nevertheless prefer to assign price level targeting to the central bank. Price level targeting thus appears to have more advantages than what is commonly acknowledged.

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1 Introduction

"Price stability" is often a recommended goal for monetary policy. It has, however, been interpreted in different ways. Price stability can be interpreted as *price level* stability, that is, a stationary price level with low variance. In practice, it has often been interpreted as low and stable *inflation*. As is well known, unless above-average inflation is followed by below-average inflation, this interpretation results in 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, which is obviously quite far from literal price stability. I shall 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.

In the real world, there are currently several monetary policy regimes with explicit or implicit inflation targeting (see Haldane (1995) and Leiderman and Svensson (1995)), but there are no regimes with explicit or implicit price-level targeting. Sweden during the 1930s may so far be the only regime in history with explicit price-level targeting (cf. Fisher (1934), Jonung (1979), Black and Gavin (1990) and Berg and Jonung (1998)).

Even if there are no current examples of price-level target regimes, price-level targeting has received increasing interest in the monetary policy literature, and several recent papers compare inflation targeting and price-level targeting. A number of these papers are collected in Bank of Canada (1994), and Duguay (1994) summarizes these and some of the other papers and provides a thorough discussion of the issues involved; see also Fischer (1994) and Goodhart and Viñals (1994). Some papers compare inflation and price-level targeting by simulating the effect of postulated reaction functions (Lebow, Roberts and Stockton (1992), Fillon and Tetlow (1994), Haldane and Salmon (1995)). Other papers compare the properties of postulated simple stochastic processes for inflation and the price level (Duguay (1994), Fischer (1994)). A frequent result, emerging as the conventional wisdom, is that the choice between price-level targeting and inflation targeting involves a trade-off between low-frequency price-level variability on the one hand and high-frequency inflation and output variability on the other.[1] Thus, the advantage of price-level targeting is reduced long-term variability of the price level. This should be beneficial to long-term nominal contracts and intertemporal decisions, but 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 in the latter case, base level drift is accepted 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.[2]

Applying postulated monetary policy reaction functions, 'instrument rules', evokes the issue whether these reaction functions are optimal for reasonable objective functions and constraints of the central bank, and whether they are consistent with the realistic situation when the central bank acts under discretion and commitment to an optimal or a simple second-best rule (like those in McCallum (1990) or Taylor (1993)) is not possible (cf. Laidler (1993)). Similarly, applying postulated exogenous processes for inflation and the price level evokes the issue of whether these are consistent with a reasonable equilibrium.[3]

The purpose of this paper is to compare price-level targeting and inflation targeting, but the paper departs from the previous literature on price level versus inflation targeting by considering the *endogenous* decision rules resulting from specific central bank loss functions associated with inflation targeting and price-level targeting and the bank acting under discretion. For comparison, the corresponding endogenous decision rules under commitment are also reported, although the focus is on the discretion case. The reaction functions are hence endogenous, given central bank objectives and constraints, including available commitment technology.

The paper follows Svensson (1997a) in interpreting inflation targeting as implying not only an objective to stabilize inflation around an inflation target but, in practice, also to stabilize output (or the output gap).[4] This is motivated by the existence of target bands in actual inflation targeting regimes, indicating that some short-term inflation variability may be acceptable due to imperfect control over inflation but perhaps also in order to dampen output fluctuations; the fact that no inflation-targeting central bank seems to want to attain the inflation target at any cost (cf. Haldane (1995) and Leiderman and Svensson (1995)); and by wording in King (1995) which indicates that the inflation targeting Bank of England is not an "inflation nutter" with zero weight on output stabilization.[5] Price-level targeting is consequently interpreted as including an objective to stabilize the price level around a price-level target together with an objective to stabilize output (or the output gap).

The paper considers the realistic case with persistence in output movements. This persistence can arise in several ways, for instance due to imperfections in the labor market as in Lockwood and Philippopoulos (1994), or from sticky prices in the so-called P-bar model, recently discussed in McCallum (1994).[6]

The degree of persistence in output is indeed crucial for the results: Without persistence, a trivial trade-off between long-term price-level variability and short-term inflation variability arises. With at least moderate persistence, counter to conventional wisdom, there is *no* trade-off between price-level variability and inflation variability. Price-level targeting then results in *lower* inflation variability than inflation targeting, due to the endogenous decision rule resulting under discretion for different targets. Under inflation targeting, the decision rule is a linear feed-back rule for inflation on the output gap, since the optimal compromise between inflation and output-gap variability implies a linear relation for the two goal variables. The variance of inflation is then proportional to the variance of the output gap. Under price-level targeting, the decision rule is a linear feed-back rule for the *price level* on the output gap, since the price level replaces inflation as one of the goal variables. Inflation is then a linear function of the *first difference* of the output gap. The variance of inflation is then proportional to the variance of the first difference of the output gap. With at least moderate persistence, the variance of the first difference of the output gap is smaller than the variance of the level of the output gap.

In addition, a price-level target has the advantage of eliminating any average inflation bias resulting under discretion, in case the output target exceeds the natural rate of output. Any average inflation bias is replaced by a harmless price-level bias.

Finally, in the case when society prefers to minimize inflation variability rather than price-level variability, it may still be better off by having a price-level-targeting central bank, if there is at least moderate output persistence: The variance of inflation will be lower, any average inflation bias will disappear, and with expectations incorporating price-level targeting, output gap variability will be the same as under inflation targeting.[7]

Section 2 presents the model with an inflation-targeting central bank. Section 3 introduces a price-level-targeting central bank. Section 4 discusses the less realistic case when there is a commitment mechanism by which the central bank can commit to the optimal rule. Section 5 evaluates having a price-level-targeting central bank in the case when society has preferences corresponding to inflation targeting. Section 6 concludes. The appendix presents technical details, including some results on exogenous inflation and price-level processes.

2 Inflation targeting

The treatment of inflation targeting under persistence follows Svensson (1997a), which in turn builds on the recent extension of the analysis of rules and discretion in monetary policy to the case of persistence in Lockwood and Philippopoulos (1994), Jonsson (1995) and Lockwood, Miller and Zhang (1995).

The short-run Phillips curve is

$$y_t = \rho y_{t-1} + \alpha(\pi_t - \pi_{t|t-1}) + \varepsilon_t, \tag{2.1}$$

where y_t is the (log) output gap in period t, α and ρ are constants ($\alpha > 0$ and $0 \leq \rho < 1$), $\pi_t = p_t - p_{t-1}$ is the (log of the gross) inflation rate, p_t is the (log) price level, $\pi_{t|t-1}$ denotes inflation expectations in period $t-1$ of the inflation rate in period t, and ε_t is an iid. temporary supply shock with mean zero and variance σ^2. The private sector has rational expectations; that is,

$$\pi_{t|t-1} = \mathrm{E}_{t-1}\pi_t, \tag{2.2}$$

where E_{t-1} denotes expectations conditional upon information available in period $t-1$, which includes the realization of all variables up to and including period $t-1$, as well as the constant parameters of the model.

The short-run Phillips curve can be interpreted and motivated in several ways. It is identical to the Phillips curve used in Lucas (1973), where it is motivated by imperfect information about the general price level. More realistically, it may refer to a situation in which nominal wages for period t are set one period in advance, based on expectations in period $t-1$, without knowing the supply shock ε_t in period t. The autoregressive term then arises, for instance, as in the wage-setting model in Lockwood and Philippopoulos (1994), where trade unions set nominal wages one period in advance, disregarding non-union workers' preferences and only taking into account union members' preferences for real wages and employment, and where union membership depends on previous employment.[8]

Thus (2.1) and (2.2) represent the constraints facing the central bank. What about the central bank's objectives? As in Svensson (1997a), Fischer (1996), King (1996) and Taylor (1996), I interpret inflation targeting as stabilizing inflation around a given (long-run) inflation target, π^* (say 2 percent per year), as well as stabilizing the output gap around an output gap target, y^*. This can be represented by an intertemporal loss function for the central bank given by

$$\mathrm{E}_t \left[\sum_{\tau=t}^{\infty} \beta^{\tau-t} L_\tau \right], \tag{2.3}$$

with the period loss function

$$L_t = \frac{1}{2} \left[(\pi_t - \pi^*)^2 + \lambda (y_t - y^*)^2 \right], \tag{2.4}$$

where $\lambda > 0$ is the relative weight on output-gap stabilization.

The output-gap target y^* is taken to be nonnegative, $y^* \geq 0$. A zero output-gap target, $y^* = 0$, can be interpreted (cf. Taylor (1996) and Svensson (1996, 1998)) as a situation when there is *no* long-run output target, in the sense that the long-run output target is not subject to choice but given by the capacity level of output. A positive output-gap target, $y^* > 0$, can be interpreted as a situation in which distortions in the economy, for instance in the labor market, cause the socially preferred output level to exceed the natural output level, which, in turn, affects the central bank's loss function due to political pressure or other circumstances. A positive output-gap target introduces an average benefit from inflation surprises and causes an average inflation bias under discretion. For the purpose of this paper, it is not important whether the output-gap target for monetary policy is (rationally) zero, or (irrationally) positive.

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. Although the current supply shock is observed both by the central bank and the private sector, the assumption behind the Phillips curve (2.1) that some prices or wages are set in advance and predetermined by previous expectations, makes monetary policy effective.[9]

The decision problem of the central bank can be written

$$\hat{V}(y_{t-1}) = \mathrm{E}_{t-1} \min_{\pi_t} \left\{ \frac{1}{2} \left[(\pi_t - \pi^*)^2 + \lambda (y_t - y^*)^2 \right] + \beta \hat{V}(y_t) \right\}, \tag{2.5}$$

where the minimization in period t is subject to (2.1) but is done for given inflation expectations $\pi_{t|t-1}$. The central bank thus no longer internalizes the effect of its decisions on inflation expectations, although it takes into account that changes in the current output gap will affect current expectations of future inflation (which is incorporated in $\hat{V}(y_t)$). The indirect loss function can be written

$$\hat{V}(y_{t-1}) = \hat{\gamma}_0 + \hat{\gamma}_1 y_{t-1} + \frac{1}{2} \hat{\gamma}_2 y_{t-1}^2. \tag{2.6}$$

In Svensson (1997b), it is shown that the decision rule and the output gap fulfill[10]

$$\pi_t = \hat{a} - \frac{\hat{b}}{1 - \alpha \hat{b}} y_t = \hat{a} - \frac{\hat{b}}{1 - \alpha \hat{b}} \rho y_{t-1} - \hat{b} \varepsilon_t, \tag{2.7}$$

$$y_t = \rho y_{t-1} + (1 - \alpha\hat{b})\varepsilon_t. \tag{2.8}$$

The constants are given by

$$\hat{a} = \pi^* + \lambda\alpha y^* - \beta\alpha\hat{\gamma}_1 \geq \pi^* + \lambda\alpha y^*, \quad \hat{b} = \frac{(\lambda + \beta\hat{\gamma}_2)\,\alpha}{1 + (\lambda + \beta\hat{\gamma}_2)\,\alpha^2} > 0, \tag{2.9}$$

where

$$\hat{\gamma}_1 = -\frac{\lambda y^* \left[1 + (\lambda + \beta\hat{\gamma}_2)\,\alpha^2\right]\rho}{1 - \beta\rho\left[1 + (\lambda + \beta\hat{\gamma}_2)\,\alpha^2\right]} \leq 0, \tag{2.10}$$

$$\hat{\gamma}_2 = \frac{1 - \beta\rho^2 - 2\lambda\beta\alpha^2\rho^2 - \sqrt{(1 - \beta\rho^2)^2 - 4\lambda\beta\alpha^2\rho^2}}{2(\beta\alpha\rho)^2} > 0. \tag{2.11}$$

As explained in Svensson (1997b), an existence condition for the parameters must be fulfilled.

The results under discretion are summarized in table 1, the column for Inflation targeting. The output gap follows an AR(1) process (row 1). Inflation can be written as a linear function of the current output gap, with a negative coefficient (since $\hat{b}$ by (2.9) fulfills $\alpha\hat{b} < 1$) (row 3). It can also be written as a linear function of the lagged output gap and the current supply shock, (2.7).

The average inflation bias, $\mathrm{E}[\pi_t] - \pi^*$, is given in row (4). If the output-gap target is zero, $y^* = \hat{\gamma}_1 = 0$ and there is no average inflation bias. If the output-gap target is positive, the average inflation bias is positive.

The unconditional variance of inflation is proportional to the unconditional variance of the output gap and given in row 5. The price level is an I(1) process given in row 6, hence its variance is infinite (row 7).

Table 1. Discretion

		Inflation targeting	Price-level targeting
(1)	y_t	$\rho y_{t-1} + (1 - \alpha\hat{b})\varepsilon_t$	$\rho y_{t-1} + (1 - \alpha\hat{b})\varepsilon_t$
(2)	$\mathrm{Var}\,[y_t]$	$\frac{(1-\alpha\hat{b})^2}{1-\rho^2}\sigma^2$	$\frac{(1-\alpha\hat{b})^2}{1-\rho^2}\sigma^2$
(3)	π_t	$\hat{a} - \frac{\hat{b}}{1-\alpha\hat{b}} y_t$	$\pi^* - \frac{\hat{b}}{1-\alpha\hat{b}}(y_t - y_{t-1})$
(4)	$\mathrm{E}\,[\pi_t] - \pi^*$	$\lambda\alpha y^* - \beta\alpha\hat{\gamma}_1$	0
(5)	$\mathrm{Var}\,[\pi_t]$	$\frac{\hat{b}^2}{1-\rho^2}\sigma^2$	$\frac{2\hat{b}^2}{1+\rho}\sigma^2$
(6)	p_t	$p_{t-1} + \hat{a} - \frac{\hat{b}}{1-\alpha\hat{b}} y_t$	$\hat{a}_t - \frac{\hat{b}}{1-\alpha\hat{b}} y_t$
(7)	$\mathrm{Var}\,[p_t]$	∞	$\frac{\hat{b}^2}{1-\rho^2}\sigma^2$

3 Price-level targeting

The Phillips curve (2.1) can be written

$$y_t = \rho y_{t-1} + \alpha(p_t - p_{t|t-1}) + \varepsilon_t, \tag{3.1}$$

since $\pi_t - \pi_{t|t-1} = p_t - p_{t|t-1}$, where $p_{t|t-1}$ denotes the expectations in period $t-1$ of the (log) price level in period t. The private sector's rational expectations imply

$$p_{t|t-1} = \mathrm{E}_{t-1} p_t. \tag{3.2}$$

A price-level-targeting central bank is assumed to have the period loss function

$$L_t = \frac{1}{2}\left[(p_t - p_t^*)^2 + \lambda(y_t - y^*)^2\right], \tag{3.3}$$

where p_t^* is the (log) price-level target. In order to be consistent with the inflation target of an inflation-targeting central bank, the price-level target fulfills

$$p_t^* = p_{t-1}^* + \pi^*. \tag{3.4}$$

The previous assumption that the central bank has perfect control over inflation implies perfect control over the price level. It sets the price level in each period after having observed the current supply shock ε_t.

Under discretion, the decision problem of the central bank can be written

$$\hat{V}(y_{t-1}) = \mathrm{E}_{t-1} \min_{p_t} \left\{ \frac{1}{2}\left[(p_t - p_t^*)^2 + \lambda\,(y_t - y^*)^2\right] + \beta \hat{V}(y_t) \right\}, \tag{3.5}$$

where the minimization in period t is subject to (2.1). It takes the price-level expectations $p_{t|t-1}$ as given, but takes into account that changes in the current output gap will affect price-level expectations $p_{t+1|t}$ (this is incorporated in $\hat{V}(y_t)$).

Except for the change in variables from π_t to p_t, the decision problem is the same as under inflation targeting. Thus, the indirect loss function will be the same as under inflation targeting. By the same argument as above, the price level fulfills

$$p_t = \hat{a}_t - \frac{\hat{b}}{1 - \alpha\hat{b}} y_t = \hat{a}_t - \frac{\hat{b}}{1 - \alpha\hat{b}} \rho y_{t-1} - \hat{b}\varepsilon_t, \tag{3.6}$$

with

$$\hat{a}_t = p_t^* + \lambda\alpha y^* - \beta\alpha\hat{\gamma}_1, \tag{3.7}$$

where $\hat{b}$ is given by (2.9), $\hat{\gamma}_1$ and $\hat{\gamma}_2$ are given by (2.10) and (2.11). The output gap will behave as (2.8).

The price level under price-level targeting behaves exactly as inflation under inflation targeting, with an average *price-level* bias instead of an inflation bias (if the output-gap target is positive). The price-level will be trend-stationary, with finite unconditional variance (of the deviation from the trend).

The results are summarized in table 1, the column for Price-level targeting. Inflation (row 3) will be given by

$$\pi_t = p_t - p_{t-1} = \pi^* - \frac{\hat{b}}{1-\alpha\hat{b}}(y_t - y_{t-1}), \tag{3.8}$$

where I have used (3.4). We see that there is no average inflation bias under price-level targeting (row 4).

Thus, comparing inflation under inflation targeting and price-level targeting, we note that inflation under inflation targeting is a linear function of the output gap, whereas under price-level targeting inflation is the same linear function of the *first-difference* of the output gap (row 3). Hence, the ranking of the unconditional variance of inflation under inflation targeting and price-level targeting simply depend on the ranking of the unconditional variance of the level and first-difference of the output gap. If the output gap is sufficiently persistent, the variability of its first-difference is less than the variability of its level.

More precisely, since the output gap follows the same AR(1) process under both regimes, the unconditional variances of the level and first-difference are related as[11]

$$\mathrm{Var}\left[y_t - y_{t-1}\right] = 2(1-\rho)\mathrm{Var}\left[y_t\right]. \tag{3.9}$$

Since the unconditional variance of the first-difference of the output gap is lower than the unconditional variance of the output gap if $\rho > \frac{1}{2}$, it follows that the unconditional variance of inflation is lower under price-level targeting if the output gap is at least moderately persistent. If $y^* = 0$, $\rho > \frac{1}{2}$ is both necessary and sufficient for a lower variance of inflation under price-level targeting; if $y^* > 0$, $\rho > \frac{1}{2}$ is sufficient but not necessary.

4 Commitment

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

$$\pi_t = \pi^* - b^*\varepsilon_t \tag{4.1}$$

where

$$b^* = \frac{\lambda\alpha}{1 + \lambda\alpha^2 - \beta\rho^2} < \hat{b} \tag{4.2}$$

(see Svensson (1997a) for the derivation). The output gap will then fulfill

$$y_t = \rho y_{t-1} + (1 - \alpha b^*)\varepsilon_t. \tag{4.3}$$

Thus, under commitment, 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; any dependence on previous information known by the private sector would just go into expected inflation, which would add to the loss function without affecting the output gap. There is no average inflation bias.

The results are summarized in table 2, the column for Inflation targeting. The unconditional variance of inflation (row 3) follows directly from (4.1). The price level is a random walk (row 4), with infinite unconditional variance (row 5).

Table 2. Commitment

		Inflation targeting	Price-level targeting
(1)	π_t	$\pi^* - b^*\varepsilon_t$	$\pi^* - b^*(\varepsilon_t - \varepsilon_{t-1})$
(2)	$\mathrm{E}[\pi_t]$	π^*	π^*
(3)	$\mathrm{Var}[\pi_t]$	$b^{*2}\sigma^2$	$2b^{*2}\sigma^2$
(4)	p_t	$p_{t-1} + \pi^* - b^*\varepsilon_t$	$p_t^* - b^*\varepsilon_t$
(5)	$\mathrm{Var}[p_t]$	∞	$b^{*2}\sigma^2$

Under commitment, the optimal rule under price-level targeting is identical to that under inflation targeting, except that p_t and p_t^* replace π_t and π^*. Thus the price level follows

$$p_t = p_t^* - b^*\varepsilon_t, \tag{4.4}$$

with b^* given by (4.2). The output gap will then fulfill (4.3).

The results are summarized in table 2, the column for Price-level targeting. The price level is trend-stationary with finite variance around the trend (rows 4 and 5). Inflation (row 1) fulfills

$$\pi_t = p_t - p_{t-1} = \pi^* - b^*(\varepsilon_t - \varepsilon_{t-1}).$$

Therefore, the unconditional variance of inflation is twice the variance under inflation targeting (row 3).

Thus, under commitment, the conventional wisdom that price-level targeting brings higher inflation variability is true, since commitment removes the realistic persistence of inflation and the price level. Under inflation targeting, the optimal rule under commitment is to let inflation respond only to the new information, that is, the supply shock, which has arrived after expectations were formed, and inflation variability will be proportional to the variance of the supply shock. Similarly, under price-level targeting, the optimal rule is to let the price level respond only to the supply shock. Then inflation will depend on the first-difference of the supply shock. Hence, variability of inflation will be proportional to twice the variance of the supply shock, since the new information is, by definition, iid.

McCallum (1995, 1997) has argued that the central bank can, in practice, choose the commitment policy even if no commitment technology is available, that is, the bank can *just do it*. If one accepts McCallum's argument, the main message of this paper is overturned. However, I believe that for McCallum's argument to be valid, McCallum must provide a reasonable explicit model where his suggested outcome is an equilibrium. The fact is that *just do it* is not subgame perfect (that is, consistent with backward induction) in existing standard models, absent a commitment mechanism. The bank always has an incentive to renege, for instance by deviating in the current period and promising to follow the optimal rule from the next period and onwards.

The apparent absence of an inflation bias in some cases of real-world monetary policy is sometimes taken as an indication that the optimal rule is followed. I do not find this argument convincing. The absence of an inflation bias is more convincingly explained by central bank objectives being consistent with the natural rate hypothesis, for instance, that the output-gap target y^* is zero rather than positive. Furthermore, as any serious student of monetary policy knows, central banks frequently reconsider their monetary policy more or less from scratch, without being bound by previous decisions. Besides, if, in period 1, a central bank can commit itself to following a particular policy rule forever, how come it is not already committed by decisions made in period 0 or earlier? For several reasons, the commitment equilibrium is, at best, a useful reference point, but not a good description of actual monetary policy.[12] [13]

5 Price-level targeting even if society has inflation target preferences?

Sections 2 and 3 above have examined the equilibria resulting if the central bank targets inflation or the price level. So far, nothing has been said about what the social preferences for monetary policy might be. Deriving the objectives for monetary policy from a social welfare function related to individual agents' preferences over consumption and leisure is beyond the scope of this paper. In this section, I will instead answer a much simpler question: Suppose that social preferences for monetary policy simply correspond to either inflation targeting, (2.3) and (2.4), or price-level targeting, (2.3) and (3.3). Suppose, furthermore, that society can assign any of these loss functions (but no other) to a central bank that has no commitment technology and acts under discretion. Which of the two loss functions should society assign to the central bank?

If social preferences correspond to price-level targeting, it is obvious that it is better to assign price-level targeting to the central bank. An inflation-targeting central bank would result in the same output gap behavior, but the base drift in the price level would make the price level non-trend-stationary, with price-level variability increasing without bound with the horizon. In addition, if the output-gap target were positive, the price level would on average grow faster than the price-level target.

If social preferences correspond to inflation targeting, would it be better to assign inflation targeting to the central bank? The answer is no, if there is at least moderate output-gap persistence. The reason why price-level targeting is better is, intuitively, that it (i) causes less inflation variability and (ii) results in the same output-gap behavior. This is enough to make price-level targeting better. If the output-gap target is positive, price-level targeting has an additional benefit since it (iii) eliminates any average inflation bias.

A rigorous argument, which compares the resulting social indirect loss functions, is reported in the appendix.

This result can be further illuminated by a direct comparison of the decision rules. Under inflation targeting, the optimal decision rule under commitment is (4.1). Due to (4.3), it can be written

$$\pi_t = \pi^* - \frac{b^*}{1 - \alpha b^*}(y_t - \rho y_{t-1}). \tag{5.1}$$

An inflation-targeting central bank under discretion delivers the decision rule

$$\pi_t = \hat{a} - \frac{\hat{b}}{1 - \alpha \hat{b}} y_t, \tag{5.2}$$

where $\hat{a} \geq \pi^*$ and $\hat{b} > b^*$. A price-level-targeting central bank under discretion delivers the decision rule

$$\pi_t = \pi^* - \frac{\hat{b}}{1 - \alpha \hat{b}}(y_t - y_{t-1}). \tag{5.3}$$

Under discretion, it is clear that a price-level targeting central bank may deliver a better approximation to the optimal decision rule (5.1) than an inflation-targeting central bank: The coefficient $\frac{\hat{b}}{1-\alpha\hat{b}}$ is the same under both kinds of targeting (although larger than under commitment). The output-gap behavior is the same. With enough output-gap persistence, the first difference of the output gap, $y_t - y_{t-1}$, is a better approximation of the unanticipated change in the output gap, $y_t - \rho y_{t-1}$, than the output gap, y_t. This is sufficient to make a price-level targeting central bank preferable. If the output-gap target is positive, there is an additional benefit of no average inflation bias under price-level targeting.[14]

This comparison of decision rules also reveals that a price-level-targeting central bank under discretion does not deliver the optimal rule for inflation targeting under commitment. Svensson (1997a) examines how modified inflation targets can improve the discretionary equilibrium with persistence in output and makes comparisons with Rogoff (1985) 'conservative' central banks and with Walsh (1995)-Persson and Tabellini (1993) linear inflation contracts.

6 Conclusions

According to an emerging, although not completely unanimous (cf. Fillon and Tetlow (1994)), conventional wisdom, the choice between price-level targeting and inflation targeting involves a trade-off between (i) low-frequency price-level variability and (ii) high-frequency inflation and output variability. This conventional wisdom arises from the use of exogenous reaction functions or exogenous inflation and price-level processes, which may or may not be consistent with objectives and constraints (including commitment technologies) faced by central banks. In contrast, this paper examines price-level and inflation targeting by deriving endogenous decision rules and equilibrium price level and inflation processes, when central banks have been assigned price level or inflation targets and, realistically, act under discretion and face persistent output movements.

In this framework, price-level targeting naturally results in a lower low-frequency price-level variability than inflation targeting. However, if output persistence is, at least, moderate, it also results in lower high-frequency inflation variability, counter to conventional wisdom. The reason is that under inflation targeting, inflation depends on the output gap, whereas under price-level targeting, inflation depends on the *change* in the output gap; with sufficient persistence, the change in the output gap is less variable than the output gap itself.

If the output target is higher than the natural output level, price-level targeting has the additional advantage of eliminating the average inflation bias which then results under inflation targeting.

In case society's preferences correspond to price-level targeting, price-level targeting is clearly better than inflation targeting, since the latter results in a non-trend-stationary price level and, if there is an inflation bias, in a price level that increasingly deviates from the target price level. In case society's preferences correspond to inflation targeting, because of the reduced inflation variability, it is *still* better for society to assign a price level target to the central bank (if the output-gap persistence is at least moderate). (The elimination of any average inflation bias is an additional benefit.) This result can also be understood with reference to the optimal rule under commitment. Under commitment and inflation targeting, inflation depends only on the new information that has arrived after private sector expectations were formed; in this case the supply shock. Under discretion and inflation targeting, inflation depends on the output gap; under price-level targeting, inflation depends on the change in the output gap; when the output gap is persistent, the latter is a better approximation of the supply shock than the former.

The paper has demonstrated the importance of output persistence for obtaining these results and, I hope, the benefits of deriving endogenous decision rules for assigned targets rather than using postulated reaction functions when comparing inflation targeting and price-level targeting.

In the model used here, price-level targeting and inflation targeting result in the same output variability, since both regimes result in the same conditional one-period variance of the price level and the inflation rate (although the unconditional variability of one-period inflation, and the conditional more-than-one-period variance of the price level and inflation rate, are lower under price-level targeting), and only the unanticipated part of one-period price movements affect output.

However, if nominal wages are downwardly rigid, anticipated negative inflation (deflation) would increase real wages and increase output. This may increase output variability; in particular it may reduce *average* output. For given inflation variability, the effect depends on the average inflation rate, regardless of whether price-level or inflation targeting is pursued. Hence, the effect is an argument for a small positive inflation target under inflation targeting and a price-level target that increases at a steady rate during price-level targeting, since that would reduce the frequency of deflation. However, the reduced variability of inflation under price-level targeting still seems to be an argument in favor of price-level targeting. Productivity growth will, in any case, reduce the effect.

Nonnegative nominal interest rates have also been used as an argument for a low, positive inflation rate, since low or negative inflation could then result in too high real interest rates, and in particular prevent monetary policy from being sufficiently expansionary in recessions. For a given average inflation rate, the reduced inflation variability under price-level targeting once more seems to speak in favor of price-level targeting.

In any case, to the extent that downwardly rigid nominal wages and nonnegative nominal interest rates imply a positive average inflation rate, a price-level target which increases at a steady rate incurs no principal difficulty, since the predictability of the price level is not reduced.

The parameters of the Phillips curve (the slope, the degree of persistence, and the variance of supply shocks) might not be invariant to a shift from inflation targeting to price-level targeting. It is not obvious, however, whether the parameters are likely to change and if so, in what direction, especially since conditional variances (and average inflation in case the output target equals the natural rate) are the same in the two regimes. Clearly a more elaborate analysis, with explicit microfoundations of the Phillips curve, is then required.

Will random walk measurement errors of the price level provide an argument against price-level targeting? No, for if there are such measurement errors, there will be an unavoidable random walk component to the 'true' price level, but inflation targeting will add another random walk component, making the variance of the price level still higher under inflation targeting than under price-level targeting.

What is the effect of control errors? Suppose there are iid. control errors, η_t, on the price level, with variance σ_η^2. Under inflation targeting, this will add σ_η^2 to the variance of inflation. Under price-level targeting, this will be added twice to the variance of inflation, which means that the degree of persistence must be somewhat higher (than 0.5) in order to make the inflation variance lower under price-level targeting (unless the variance due to control errors is so large as to dominate all other sources of variability).

Do social preferences correspond to inflation targeting, price-level targeting, or something else? Deriving the objectives for monetary policy from some social welfare function over private agents' preferences is definitely beyond the scope of this paper. One issue that must be dealt with in such an undertaking is what the social benefits of reduced long-term uncertainty of the price level are. This seems, unfortunately, to be an under-researched area (see Konieczny (1994) and Duguay (1994) for discussion).

A Evaluation of price-level targeting with inflation-targeting preferences

The equilibria resulting from either an inflation-targeting or a price-level-targeting central bank will be evaluated with a social loss function corresponding to inflation targeting.

With an inflation-targeting central bank, the relevant social indirect loss function is the same as defined in the decision problem (2.5), $\hat{V}(y_{t-1})$, and given by (2.6), with coefficients $\hat{\gamma}_1$ and $\hat{\gamma}_2$ given by (2.10) and (2.11). Identification of $\hat{\gamma}_0$ in (2.6) results in

$$\hat{\gamma}_0 = \frac{1}{1-\beta}\frac{1}{2}\left\{(\hat{a}-\pi^*)^2 + \lambda y^{*2} + \left[\hat{b}^2 + (\lambda + \beta\hat{\gamma}_2)(1-\alpha\hat{b})^2\right]\sigma^2\right\}. \tag{A.1}$$

With a price-level-targeting central bank, the relevant social indirect loss function, denoted by $V^p(y_{t-1})$, is defined as

$$V^p(y_{t-1}) = \mathrm{E}_{t-1}\left\{\frac{1}{2}\left[(\pi_t - \pi^*)^2 + \lambda\,(y_t - y^*)^2\right] + \beta V^p(y_t)\right\}, \tag{A.2}$$

where (3.8) and (2.8) are substituted for π_t and y_t. This value function will be quadratic and can be written as

$$V^p(y_{t-1}) = \gamma_0^p + \gamma_1^p y_{t-1} + \frac{1}{2}\gamma_2^p y_{t-1}^2, \tag{A.3}$$

where coefficients γ_0^p, γ_1^p and γ_2^p remain to be determined.

Hence, the difference between the two social indirect loss functions is

$$V^p(y_{t-1}) - \hat{V}(y_{t-1}) = (\gamma_0^p - \hat{\gamma}_0) + (\gamma_1^p - \hat{\gamma}_1)y_{t-1} + \frac{1}{2}(\gamma_2^p - \hat{\gamma}_2)y_{t-1}^2. \tag{A.4}$$

Let me start with the first term on the right-hand side of (A.4). Identification of the constant γ_0^p in (A.2) and (A.3) results, after some algebra, in

$$\gamma_0^p = \frac{1}{1-\beta}\frac{1}{2}\left\{\lambda y^{*2} + \left[\hat{b}^2 + (\lambda + \beta\gamma_2^p)(1-\alpha\hat{b})^2\right]\sigma^2\right\}. \tag{A.5}$$

From (A.5) and (A.1) we then have

$$\gamma_0^p - \hat{\gamma}_0 = \frac{1}{1-\beta}\frac{1}{2}\left\{-(\hat{a}-\pi^*)^2 + \beta(\gamma_2^p - \hat{\gamma}_2)(1-\alpha\hat{b})^2\sigma^2\right\}. \tag{A.6}$$

The first term on the right-hand side is nonpositive. It obviously arises because the price-level target equilibrium has no average inflation bias. The second term depends on the difference between coefficients γ_2^p and $\hat{\gamma}_2$, that is, the convexity of the indirect loss function. Identification of γ_2^p in (A.2) and (A.3) gives

$$\gamma_2^p = \frac{\lambda\rho^2 + \left(\frac{\hat{b}}{1-\alpha\hat{b}}\right)^2(1-\rho)^2}{1-\beta\rho^2}. \tag{A.7}$$

In order to facilitate comparison, by (2.9) and the stationary version of (A3) in Svensson (1997b), $\hat{\gamma}_2$ can be written as[15]

$$\hat{\gamma}_2 = \frac{\lambda\rho^2 + \left(\frac{\hat{b}}{1-\alpha\hat{b}}\right)^2\rho^2}{1-\beta\rho^2}. \tag{A.8}$$

[15] Note that by (2.9) $(\lambda+\beta\hat{\gamma}_2)\alpha = \frac{\hat{b}}{1-\alpha\hat{b}}$. Use this in the second term on the right-hand side of (A3) in Svensson (1997b).

Hence,

$$\gamma_2^p - \hat{\gamma}_2 = \frac{\left(\frac{\hat{b}}{1-\alpha\hat{b}}\right)^2 \left[(1-\rho)^2 - \rho^2\right]}{1-\beta\rho^2} = \frac{\left(\frac{\hat{b}}{1-\alpha\hat{b}}\right)^2 (1-2\rho)}{1-\beta\rho^2}. \tag{A.9}$$

The difference between γ_2^p and $\hat{\gamma}_2$ is negative when $\rho > \frac{1}{2}$, since the inflation rate is less sensitive to lagged output under price-level targeting if $\rho > \frac{1}{2}$. A given level of y_{t-1} in period $t-1$ will give rise to a squared inflation term in period t equal to $\left(\frac{\hat{b}}{1-\alpha\hat{b}}\right)^2 (1-\rho)^2 y_{t-1}^2$ under a price-level target and equal to $\left(\frac{\hat{b}}{1-\alpha\hat{b}}\right)^2 \rho^2 y_{t-1}$ under an inflation target (the present value of a future sequence of such terms requires discounting by $\beta\rho^2$).

Finally, let me look at the second term in (A.4), corresponding to the linear term in the value functions. Identifying the linear term in (A.2) and (A.3) gives

$$\gamma_1^p = -\frac{\lambda y^* \rho}{1-\beta\rho}. \tag{A.10}$$

In order to facilitate comparison, I use (2.9) and (2.10) with some algebra to rewrite $\hat{\gamma}_1$ in terms of the average inflation bias,[16]

$$\hat{\gamma}_1 = -\frac{\lambda y^* \rho + (\hat{a} - \pi^*)\frac{\hat{b}}{1-\alpha\hat{b}}\rho}{1-\beta\rho}. \tag{A.11}$$

Hence

$$\gamma_1^p - \hat{\gamma}_1 = \frac{(\hat{a} - \pi^*)\frac{\hat{b}}{1-\alpha\hat{b}}\rho}{1-\beta\rho} \geq 0. \tag{A.12}$$

This difference is positive, when the output-gap target is positive. Then an increase in y_{t-1} reduces the loss function further under inflation targeting: the resulting reduction in π_t is more beneficial when the average inflation bias is positive under inflation targeting.

The unconditional mean of (A.4) is

$$\mathrm{E}\left[V^p(y_{t-1}) - \hat{V}(y_{t-1})\right] = \gamma_0^p - \hat{\gamma}_0 + \frac{1}{2}(\gamma_2^p - \hat{\gamma}_2)\mathrm{Var}\left[y_{t-1}\right]. \tag{A.13}$$

This is strictly negative for $\rho > \frac{1}{2}$.

[16] Write (2.10) as

$$\hat{\gamma}_1 = -\frac{\lambda y^* \rho + \lambda\alpha y^* c}{1-\beta\rho-\beta\alpha c},$$

where $c = (\lambda + \beta\hat{\gamma}_2)\alpha\rho = \frac{\hat{b}}{1-\alpha\hat{b}}\rho$. Rewrite this as

$$\hat{\gamma}_1 = -\frac{\lambda y^* \rho + (\lambda\alpha y^* - \beta\alpha\hat{\gamma}_1)\, c}{1-\beta\rho}$$

and use (2.9).

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[1]The result is emphasized in Lebow, Robert and Stockton (1992), Fischer (1994), and Haldane and Salmon (1995). In contrast, Fillon and Tetlow (1994) report that in their simulations, price level targeting results in *less* inflation variability but in more output variability than inflation targeting. No explanation is offered beyond the observation that the results indicate strong serial correlation of the price level. Duguay (1994) does not report the unconditional variance of one-period inflation rates in his examination of different processes for inflation and the price level, although this variance is actually less under price level targeting for some of the parameters studied (see the appendix of Svensson (1997b)).

[2]Hall (1984, 1986) provides arguments for price stability. McCallum (1990) argues that price level targeting provides a relatively small gain in long-run price predictability, since price level variability (for the U.S.) is already relatively small under inflation targeting. Gerlach (1993) interprets inflation targets as a 'target zone' for the price level. Balke and Emery (1994) examine what monetary policy rules are consistent with inflation and price level targeting (which they refer to as Weak and Strong Price Stability). Scarth (1994), Crawford and Dupasquier (1994), and Konieczny (1994) discuss various aspects of price targeting and inflation targeting. Smith (1994) shows that price-level targeting may have better determinacy and welfare properties than inflation targeting, in an overlapping-generations model with perfect foresight and commitment.

Base drift in money supply is distinct from base drift in the price level. As shown by Walsh (1986), some degree of money supply base drift is warranted even with price level stability, if there are permanent shocks to money demand and output.

[3]Furthermore, as shown in the appendix of Svensson (1997b), if the exogenous processes are not constants plus an iid error but AR(1)s, that is, with some persistence, the ranking of inflation variability under inflation and price-level targeting becomes an open issue.

[4]Svensson (1997a) argues that inflation targeting regimes should be interpreted as, in prac-

tice, also having output targets, and compares inflation targeting regimes to (1) Rogoff (1985) 'weight-conservative' central banks with more weight on inflation stabilization, (2) 'linear inflation contracts' proposed by Walsh (1995) and extended by Persson and Tabellini (1993), and (3) 'output targeting' regimes, both with and without persistence in output. For instance, without persistence, an optimal inflation target equal to the socially best inflation rate less any discretionary inflation bias is identical to a linear inflation contract and better than having a Rogoff 'weight-conservative' central bank.

[5]Recently, Fischer (1996), King (1996) and Taylor (1996), at the August 1996 Jackson Hole conference sponsored by the Federal Reserve Bank of Kansas City, all interpreted inflation targeting as also involving some output stabilization.

[6]On the P-bar model, see footnote 8.

[7]The consequences of downward nominal rigidity and nonnegative nominal interest rates are briefly discussed in the concluding section.

[8]However, as shown in the appendix of Svensson (1997b), the Phillips curve with output persistence is also consistent with a variant of the so-called P-bar model of sticky prices recently discussed in McCallum (1994). Then there are permanent supply shocks that make the natural output level (the capacity level) follow a random walk. The price level is sticky and inflation is determined by the lagged output gap (the difference between aggregate demand and the capacity level), expected inflation in the 'equilibrium' price level (corresponding to the natural output level), actual inflation in the equilibrium price level, and a temporary supply shock. (The effect of the permanent supply shock on the output gap vanishes and only the temporary supply shock enters in (2.1).)

[9]As shown in the appendix, the results are not affected if the central bank uses money supply as an instrument and money supply affects aggregate demand. The results are also the same if the central bank uses an interest rate as its instrument, and aggregate demand is affected by the interest rate (cf. Rogoff (1985) and McCallum (1994)). A control error on the price level will, however, affect the results somewhat, as explained below.

[10]The equilibrium concept is a Markov-perfect equilibrium where trigger strategies are not allowed and actions depend on history only via the lagged state variable, y_{t-1} (cf. Lockwood and Philippopoulos (1994)).

[11]Let $y_t = \rho y_{t-1} + z_t$ and $\Delta y_t = (\rho - 1)y_{t-1} + z_t$. Then $\mathrm{Var}[\Delta y_t] = (1-\rho)^2 \mathrm{Var}[y_t] + \mathrm{Var}[z_t] = 2(1-\rho)\mathrm{Var}[y_t]$, where I have used $\mathrm{Var}[z_t] = (1-\rho^2)\mathrm{Var}[y_t]$.

[12]Blinder (1998) concludes that discretion without inflation bias is a relevant description of U.S. monetary policy.

[13]McCallum (1997) explicitly states that the argument for *just do it* is not based on so-called trigger-strategy equilibria; such equilibria normally suffer from indeterminacy and the lack of a coordination mechanism for the private sector's trigger strategies due to the Folk Theorem. Still, "reputation," not related to trigger-strategy equilibrium but in the sense of the private sector's best estimate of unobservable parameters in a central bank's loss function, may serve an important role in improving monetary policy outcomes and bring the discretion equilibrium somewhat closer to the commitment equilibrium, cf. Faust and Svensson (1998).

[14]Gavin and Stockman (1991) provide a different argument why price level targeting might dominate inflation targeting, even if social preferences correspond to inflation targeting: it may reduce the central bank's incentive to create inflation for special interests and blame it on random events.