WP/05/89

IMF Working Paper

Inflation Targeting and Output Growth: Empirical Evidence for the European Union

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INTERNATIONAL MONETARY FUND

 WP/05/89

IMF Working Paper

European Department

Inflation Targeting and Output Growth: Empirical Evidence for the European Union

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Authorized for distribution by Dimitri G. Demekas

May 2005

Abstract

This paper evaluates the performance of two alternative policy rules, a forward-looking rule and a spontaneous adjustment rule, under alternative inflation targets, in terms of output losses in a macroeconomic model, using European Union data. The simulations suggest that forward-looking rules contribute to macroeconomic stability and monetary policy credibility, and that a positive inflation target, as opposed to zero inflation, leads to higher and less volatile output. These results are robust to changes in the specification of the model and time period. The same methodology applied to individual countries supports country-specific flexible inflation targeting.

JEL Classification Numbers: E31; E32; E37; E52

Keywords: Inflation targeting, European Union

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I. Introduction

Inflation targeting is a monetary policy regime that makes a low rate of inflation its primary objective.[2] Schaechter, Stone, and Zelmer (2000) and Corbo, Landerretche, and Schmidt-Hebbel (2001) identify over 15 countries that have adopted such a regime in recent years.[3] Under inflation targeting, the monetary authorities commit themselves to keeping the inflation rate close to an explicit target.[4] In strict inflation targeting, the monetary authorities minimize the variability of the inflation rate around its target, with no other variable in their objective function, while in flexible inflation targeting, the monetary authorities allow other variables to enter their objective function, such as the output gap (see Svensson (1999a)). To achieve their inflation target, the monetary authorities employ a policy reaction function. For example, according to the Taylor (1993) rule, the interest rate changes in response to deviations of the inflation rate from its target and to deviations of the output gap from zero.[5]

It has been argued that central banks can substantially improve their credibility under an inflation-targeting policy regime by becoming more accountable and transparent and by better communicating their policies (Svensson (1999b)). The relevant literature examines the performance of inflation, the credibility of monetary policy, and the magnitude of the sacrifice ratio (i.e., the cost of lowering inflation) under inflation targeting. Ammer and Freeman (1995), Freeman and Willis (1995), and Mishkin and Posen (1997) find that inflation performance improves significantly under inflation targeting, while Kahn and Parrish (1998) find evidence that inflation targeting improved policy credibility in New Zealand and Canada. However, Cecchetti and Ehrmann (2000) do not find large benefits of inflation targeting in terms of inflation performance, the cost of inflation, or the credibility of monetary policy. Siklos (1999) finds mixed evidence, with inflation targeting improving inflation performance in Australia, Canada, and Sweden, but not in Finland, New Zealand, Spain, and the United Kingdom.

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[2] See Svensson (1999a) and King (1997) for a discussion of inflation targeting and its impact on output when the economy is subject to demand and/or supply shocks.

[3] See also Bernanke, Laubach, Mishkin, and Posen (1999) for a discussion.

[4] See Ruge-Murcia (2003).

[5] Taylor (1993) has chosen the parameter values that make the predicted movements of the interest rate in his rule mimic actual movements. Since then, other papers have estimated Taylor's rule for different sample periods, different formulations of the rule, and different countries (see for example Adema (2004), Gerlach and Schnabel (1999), and Svensson (2003)).

In an inflation-targeting regime, the target inflation rate anchors expectations about inflation, decreasing the response to changes in actual inflation. Indeed, Levin, Natalucci, and Piger (2004) find that inflation targeting affects the public expectations about inflation, which can produce a self-fulfilling outcome, as expected inflation is included in various contracts, such as labor contracts. In this case, anchoring inflation expectations to target inflation keeps inflation low and stable.[6]

However, inflation targeting has received a fair amount of criticism. Since monetary policy affects inflation only with a lag, monitoring inflation performance can be a challenge (Svensson (1997b)). Furthermore, the optimal inflation rate is not known. A low inflation rate target may be preferable, but how low? Howitt (1990) compares the benefits from reducing inflation with the costs from achieving this reduction, concluding that the optimal inflation target exceeds zero. Moreover, a small positive inflation rate permits the downward adjustment of real wages in economies with sticky nominal wages, which is a common feature in most European economies (see Aiyagari (1990) and Thornton (1996)). A fully credible monetary policy should minimize any costs associated with targeting price stability (Blinder (1989)). However, Cecchetti and Ehrmann (2000) find that countries that introduced inflation targeting experienced an increase in their revealed aversion to inflation variability, thereby raising output volatility as a result.[7]

Although most countries with inflation-targeting regimes target the Consumer Price Index (CPI), core inflation targets—which remove volatile components from the overall price index—could be used instead. Bryan, Cecchetti and Wiggins (1999) and Roger (1997) have argued in favor of core inflation targeting.[8] Folkertsma and Hubrich (2001) argue that overall price indices reflect all shocks on the economy, which makes the implementation of inflation targeting difficult. Bagliano, Golinelli, and Morana (2002) argued that core inflation targeting is consistent with the forward-looking rule. Cogley and Sargent (2000) and Cecchetti and Wynne (2003) support using core inflation to determine the European Central Bank's (ECB) monetary policy, while Vega and Wynne (2003) argue that a core inflation index provides comparability across European Union (EU) members. Moreover, Breuss (2002) has suggested that monetary policy based on core inflation in the euro area would lead to lower inflation volatility, resulting in lower interest rates and, therefore, higher output.

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[6] See Bernanke, Laubach, Mishkin and Posen (1999), Alesina, Blanchard, Gali, Giavazzi, and Uhlig (2001), and Neumann and von Hagen (2002) for arguments in support of inflation targeting.

[7] See also Arestis, Caporale, and Cipollini (2002).

[8] Others recommend alternative and more sophisticated measures of inflation, such as trimmed mean indices (Bryan, Cecchetti, and Wiggins (1999)), but many countries do not have such data available.

This paper examines whether a zero or a positive inflation target would be desirable in the EU, assuming an inflation-targeting policy regime, by using a macroeconomic model to examine how the EU's economic performance would have changed if various inflation targets had been adopted.[9] According to Akerlof, Dickens, and Perry (1996 and 2000), a low, as opposed to zero, inflation rate allows for adjustments in real wages. Wyplosz (2001) has argued that the ECB's low inflation target has increased rigidities in the economy, leading to higher structural unemployment. Furthermore, low inflation targets may expose the economy to the risk of a deflation spiral. In contrast, Issing (2001) has argued that low inflation contributes to the elimination of money illusion, which, in turn, lessens the need for positive inflation rates.

Using data for selected EU countries, the paper evaluates the performance of two alternative policy rules—forward-looking and spontaneous adjustment—under alternative inflation targets—0, 2, and 4 percent—in terms of output losses, assuming the monetary authorities employ a loss function on deviations of output, inflation, and interest rates from their target values. The simulations suggest that forward-looking rules contribute to macroeconomic stability and monetary policy credibility, and that a positive inflation target, as opposed to a zero inflation target, is superior in terms of higher and less volatile output. Moreover, these results are robust to changes in the specification of the model and the time period. The same methodology applied to individual countries supports country-specific flexible inflation targeting.

II. The Model

A. The Benchmark Model

The benchmark model in the paper is a version of the IS-LM-AS model proposed by Clarida, Gali, and Gertler (1999), McCallum and Nelson (1999), Woodford (2000), and Clifton, Leon, and Wong (2001). The first equation describes the IS curve, based on which output is determined by the real interest rate:

$$y_t = a\, y_{t-1} + b\, r_t + \varepsilon_t, \quad 0 \leq a < 1,\ b < 0, \tag{1}$$

where y equals the output gap, r equals the real interest rate (the difference between the nominal interest rate and expected inflation), ε equals a demand disturbance term that obeys $\varepsilon_t = \mu\varepsilon_{t-1} + \lambda_{1t}$, with $0 \leq \mu \leq 1$, and λ_{1t} is an identical, independent distributed (i.i.d.) random variable with zero mean and variance $\sigma_{\lambda 1}{}^2$. The parameter b is negative and reflects intertemporal substitution of private demand—interest rates affect both

[9] For estimates of the Taylor rule in the euro area, see Peersman and Smets (1999).

consumption and investment according to equation (1). The equation also includes lagged output, indicating persistence effects.[10]

The second equation describes the LM curve (see Haldane and Salmon (1995)), based on which the demand for real money is determined by output and the interest rate:

$$m_t - p_t = c_0 + c_1 y_t + c_2 i_t + v_t,\ c_1 > 0,\ c_2 < 0, \qquad (2)$$

where *m-p* is real money and *v* equals a monetary disturbance term.

The third equation is an augmented Phillips curve:

$$\pi_t = k_0 + k_1 \pi_{t+1}^e + k_2 \pi_{t-1} + k_3 y_{t-1} + \theta_t, \qquad (3)$$

where π is inflation, π^e is expected inflation, θ is a real disturbance term (a cost-push shock, as in Svensson, 2000) that obeys $\theta_t = \nu\theta_{t-1} + \lambda_{2t}$, with $0 \le \nu \le 1$, and λ_{2t} is an i.i.d. random variable with zero mean and variance $\sigma_{\lambda 2}^2$. Equation (3) is an expectations- augmented Phillips curve (Blanchard (1997)), with persistence effects (Fuhrer (1996), Clarida, Gali, and Gertler (1999))—inflation responds to expected inflation at t+1 and actual inflation at t-1.

The fourth equation describes the formation of inflation expectations:

$$\pi_t^e = g_0 + g_1 \pi_{t-1}^e + g_2 \pi_{t-1} + \eta_t, \qquad (4)$$

where η is a random term. After recursive substitution, equation (4) can be rewritten as follows:

$$\pi_t^e = g_0/(1-g_1) + g_2 \sum_{i=1}^{\infty} g_1^i \pi_{t-i} + \sum_{i=0}^{\infty} g_1^i \eta_{t-i}. \qquad (4a)$$

According to (4a), expected inflation reflects past values of inflation (backward-looking expectations)—the sum of g_i coefficients must be lower than one in absolute value to ensure stability. Equations (3) and (4a), in turn, imply that inflation depends entirely on past values of inflation and the output gap.[11]

B. Policy Rules

The paper assumes that inflation targeting is based on explicit policy rules and that the monetary authorities affect the inflation rate through the short-term nominal interest rate. The last hypothesis differs from the common assumption that the

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[10] See Fuhrer (1996).

[11] We consider the euro area as a relatively closed economy. According to Peersman and Smets (1999), the external transmission channel is not statistically significant.

monetary authorities directly choose the inflation rate after observing the random shocks (Ruge-Murcia (2003)).[12]

The model described above is used to compare the performance of the policy rules, under three different inflation targets—0, 2, and 4 percent—and assuming that the monetary authorities raise the interest rate whenever actual inflation in the previous period exceeds target inflation.[13] The loss function assumes that the central bank dislikes high inflation, wide output gaps, and large interest rate fluctuations. Following Woodford (2003) and McCallum and Nelson (2004), the central bank's loss function is described by a symmetric quadratic parameterization functional form:

$$\text{Minimize } E_t \sum_{j,k,l=0} \beta^j \tfrac{1}{2} [(\pi_{t+j}-\pi^*)^2 + \omega_1 y_{t+k}^2 + \omega_2 (i_{t+l}-i_{t+l-1})^2] ,$$

where, i_t is the central bank's policy rate, E is the expectations-operator, ω_1 and ω_2 are positive parameters (less than, but not equal to one), and β is the discount factor. The parameters ω_1 and ω_2 show the policymakers' aversion to output deviations from its potential level and to interest rate fluctuations. Introducing the interest rate into the objective function eliminates the possibility of instrument instability (Holbrook (1972)).

The monetary authorities minimize the loss function subject to the model described by equations (1)-(3) (as in Clarida, Gali, and Gertler (1999), Peersman and Smets (1999), and Svensson (1999c)). The first-order conditions are

$$-\beta^j E_t(\pi_{t+j}-\pi^*)-\omega_1\beta^j E_t y_{t+k}-\beta^{j-1}c_1-\beta^{j-1}(c_1+bk_3)/k_1+\beta^j\omega_2 i_{t+l}+ k_1\beta^{j-1}\omega_2 i_{t+l-1}+\beta^{j-1}b = 0, \quad (4b)$$

Solving for the interest rate yields

$$i_{t+l}=[c_1/\beta\omega_2+b/\beta\omega_2+(c_1+b\, k_3)/\beta k_1\omega_2)]+(1/\omega_2)E_t(\pi_{t+j}-\pi^*)+(\omega_1/\omega_2)E_t y_{t+k}+k_1/\beta\, i_{t+l-1}, \quad (4c)$$

The paper uses two alternative policy rules: a forward-looking rule (FLR) (Henderson and Mckibbon (1993) and Clarida, Gali, and Gertler (1999)), in which the interest rate responds to the expected deviation of inflation from its target and the

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[12] Svensson (1999b and 2003) argues that a rule merely commits a central bank to adjust its policy instrument as necessary to ensure that the economy's future evolution satisfies a certain targeting criterion (e.g., inflation). Moreover, Taylor (2000) argues that a rule provides a benchmark against which to use discretionary policy.

[13] In practice, the monetary authorities have to decide whether to adopt a point inflation target or an inflation range around a point target. Difficulties in forecasting inflation and the paucity of successful predictions about the effects of monetary policy on inflation often lead to the adoption of a range around the target (Longworth and Freedman (2000)).

expected output gap;[14] and the spontaneous adjustment rule (SAR) (Clarida, Gali, and Gertler (1999)), in which the interest rate responds to the expected deviation of inflation from its target and the output gap.[15]

$i_t = a_1 + a_2 (E_t\pi_{t+1} - \pi^*) + a_3 E_t y_{t+1} + a_4 i_{t-1}$ forward looking (5)

and

$i_t = a_1 + a_2 (E_t\pi_{t+1} - \pi^*) + a_3 y_t + a_4 i_{t-1}$ spontaneous adjustment (6)

where $a_1 = [c_1/\beta\omega_2 + b/\beta\omega_2 + (c_1 + b\ k_3)/\beta k_1\omega_2)]$, $a_2 = (1/\omega_2)$, $a_3 = (\omega_1/\omega_2)$, and $a_4 = (k_1/\beta)$.

According to these rules, i_t is set each period so as to equate the expected value of π to a chosen target value π* (McCallum and Nelson (1999)). Both rules include the lagged interest rate, reflecting interest rate smoothing.[16] These rules provide benchmarks for comparing actual inflation and output performance with "optimal" performance in the EU.

III. Empirical Analysis

A. Data

Quarterly observations on real output (Y) as measured by GDP in 1995 prices; core prices (CP) as measured by core harmonized CPI and defined as the overall index excluding energy and food prices; the interbank nominal interest rate (i); the money supply (M) as measured by M1; and the unemployment rate (u) were obtained from various issues of the OECD's *Main Economic Indicators* over the period 1974-2001. The output gap was estimated by the Hodrick-Prescott (HP) filter, with the smoothing parameter equal to 1,600 (Hodrick and Prescott (1997)). The inflation rate is measured as the logarithmic difference in the price level. The real interest rate equals the nominal

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[14] For arguments in support of forward-looking rules, see Goodfriend and King (1997) and Jensen (2002).

[15] Such simple policy rules ignore a large amount of information about the economy, for example variables related to the labor and financial markets (Finan and Tetlow (1999)). However, Levin, Volker, and Williams (1999), Dennis (2002), and Levin and Williams (2003) obtain only small improvements from using more complicated policy rules.

[16] According to Levin, Volker, and Williams (1999), policy rules that incorporate interest rate smoothing and respond to output gap changes and to deviations of inflation from its target perform relatively well. Blinder (1999) argues that central banks often practice interest rate smoothing, to avoid the impact that large changes in the short-term interest rate can have on the stock of debt in the economy.

interest rate minus expected inflation (i.e., the Fisher interest rate equation). Throughout the paper, lower-case letters denote variables expressed in logarithms.[17]

The sample comprises the following EU countries: Germany, France, Belgium, the Netherlands, the United Kingdom, Italy, Luxembourg, Spain, Portugal, Denmark, Austria, Finland, Sweden, and Greece. Some countries in the sample, Finland, Spain and Sweden, had some form of inflation targeting before joining the euro area, as well as the United Kingdom. The aggregation of variables at the EU level is based on a weighting and aggregation system proposed by Maulon and Sarda (1999), which, after expressing all variables in euros, uses purchasing power parity (PPP) exchange rates.

Equation (4a) suggests the use of the Box and Jenkins technique for estimating expected inflation.[18] This approach implies that over the period under investigation inflation in the EU countries in the sample follows an ARMA (2, 0) model (within-the-sample forecasting), which is used to generate expected inflation. An ARMA (2, 0) model is also used to generate within-sample forecasting values for expected output (used in the estimation of the first-order condition of the optimization problem).

B. Comparative Output and Inflation Results for the EU

Table 1 reports estimates of the model parameters through the first-order condition (4b) using the generalized method of moments (GMM) methodology proposed by Hansen and Singleton (1982). Four lags of the short-term interest rate (in a stationary form), inflation, and the output gap are included as instruments. According to Davidson and MacKinnon (1993), efficiency gains from using more instruments in small samples are obtained at the cost of more biased estimates. Thus, the number of instruments is chosen to ensure parameter identification, while minimizing bias. As explained above, inflation targeting is examined based on three alternative inflation targets (0 percent, 2 percent, and 4 percent) and under the two alternative policy rules (forward looking and spontaneous adjustment). The *J*-statistic, which is asymptotically distributed as a x^2_{M-K} distribution, where M is the number of instruments and K is the number of estimated parameters, shows that the null hypothesis of valid overidentifying restrictions cannot be rejected, implying that the model performs relatively well.

Table 2 reports estimates of equations (1) through (3). All variables (except the output gap and inflation) are logarithmic deviations (except interest rates) from their steady state values.[19] The estimated coefficients behave as theory would predict.

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[17] All estimates are derived using the econometric software RATS, version 4.2, and MicroFit, version 5.1.

[18] See Box and Jenkins (1976).

[19] Unit root tests are available on request.

Sargan's instrument validity tests indicate that the chosen instruments are independent of the error term. The estimated model generates simulated values for the output gap and inflation in terms of mean and variances.

The results reported in Table 2 suggest that both rules satisfactory describe policy. In particular, the coefficients on the output gap as well as on inflation are statistically significant and have the expected sign. The lagged-rate coefficient ranges from 0.54 to 0.56, suggesting a high degree of interest rate smoothing. The current inflation and expected inflation coefficients are statistically significant and greater than one, implying that central banks increase interest rates enough to raise the real interest rate in order to reduce inflationary pressures.

The rules built with the assistance of the GMM estimates are used to generate simulated values for the output gap and inflation (equations (1) and (3), respectively). Table 3 reports the relative performance under the two alternative policy rules, along with the actual performance, employing 0, 2, and 4 percent inflation targets, for the period 1974:Q1-2001:Q4. The counterfactual experiments address the question of how the output gap and the inflation rate would have evolved over the sample period if the monetary authorities had followed either of the two optimal policy rules throughout that period.

Two interesting results emerge. First, there is a negative trade-off between the mean output gap and the mean inflation rate, as well as between the variances of the output gap and the inflation rate. The first trade-off suggests a short-run Phillips curve. The second, negative, trade-off between the variances of the output gap and the inflation rate is common in the literature (Fuhrer (1997)). According to Ball (1997) and Bean (1998), monetary authorities find it difficult to satisfy simultaneously their output gap and inflation rate targets, since the economy is continuously subjected to various supply and demand shocks. Therefore, the monetary authorities have to decide how fast to correct any divergence of the inflation rate from its target; they can chose to minimize the variance of inflation around its target at the expense of a larger output gap variation, or to maintain a small output variance and accept a more volatile inflation rate around its target. Through this decision process, the monetary authorities have to reach an optimal decision concerning the trade-off between the volatilities of output and inflation. This decision yields the optimal policy frontier, given the relative weighting of these two variables in the loss function (Cecchetti and Ehrmann (2000)).

Second, the optimal policy rules suggest that the forward-looking rule outperforms the spontaneous adjustment rule in most respects. The forward-looking rule exhibits higher mean output, lower mean inflation, smaller output gap variance, and smaller inflation variance than the alternative rule. These results are consistent with Batini and Haldane (1998) and Amano, Colletti, and Macklem (1999), who have also found that forward-looking rules lead to lower and less volatile inflation.

C. Robustness Analysis: Country Data

This section examines the robustness of the results after disaggregating to the country level. In particular, the same methodology is applied to Germany, France, Spain, and Greece—estimating the model in equations (1) through (3) for each country.[20]

Table 4 reports the output gap and inflation estimates. The results found at the aggregate level remain broadly valid for three of the four countries—Germany, France, and Spain. For Greece, the mean output gap and the mean inflation rate correlate positively, unlike the negative correlation for the aggregate results. However, Greece still exhibits a negative correlation between output gap variability and inflation variability. Since Greece experienced the highest inflation of these four countries, it could be argued that a lower inflation rate in Greece may lead to a negative correlation between mean output gap and mean inflation.

The results suggest that inflation targeting of between 2 and 4 percent in Germany, France, and Spain may result in a narrower and more stable output gap than in a zero inflation-targeting regime.[21] In contrast, a regime targeting lower inflation seems more appropriate for the Greek economy, since high inflation widens its output gap. To some extent, these results are consistent with Svensson (1999b), who has argued that flexible inflation targeting will gradually stabilize output and unemployment for certain European economies.

D. Robustness Analysis: Alternative Measures of the Output Gap

The literature on optimal monetary policy pays special attention to the methodology used to measure the output gap.[22] To test the robustness of the above results, we use an alternative method of estimating the output gap, based on a multivariate time-series model. Following Apel and Jansson (1999) and Camba-Mendez and Rodriguez-Palenzuela (2003), a three-variable system—real output, inflation, and unemployment—generates measures of the output gap, based on a structural vector autoregressive (SVAR) model with certain long-run restrictions. In particular, inflation responds only to its own structural shocks, real output responds only to its own and inflation shocks, while unemployment responds to the three shocks simultaneously. This analysis is repeated after estimating the three-variable system and obtaining the

[20] Detailed results, or results for other countries, are available on request.

[21] See also Wyplosz (2001).

[22] See Ball (1997), Clarida, Gali, and Gertler (1999), Orphanides (1999), Rudebusch (1999), Svensson and Woodford (2003), and Camba-Mendez and Rodriguez-Palenzuela (2003).

new detrended output gap data.[23] Table 5 reports the results, which nearly match those in Table 3.

In addition to VAR-constructed gap measures, we also use OECD output gaps (from the OECD's *Main Economic Indicators,* over the period 1980:Q1-2002:Q4). The results, reported in Table 6, also nearly match those in Table 3: an inflation target above zero seems to lead to smaller output gaps.

E. Robustness Analysis: An Alternative Sample Period—the 1990s

Inflation in Europe was considerably higher during the early decades of the sample, the 1970s and the 1980s. As such, appropriate inflation targets for recent years may not be appropriate targets for earlier decades. Furthermore, the variation of inflation across European countries fell dramatically in recent years, and some papers have found cyclical fluctuations in the 1990s to be smaller than those in the 1980s.[24] Thus, it is difficult to determine whether smaller fluctuations reflect inflation targeting or more favorable shocks.

This concern is addressed by reestimating and simulating the model for only the 1990s. In particular, equations (1) through (3) are estimated using quarterly data from 1990 to 2001 and are then used to generate in-sample forecasts. The results in Table 7 confirm that an inflation target above 0 percent leads to smaller output gaps, even within an environment with less frequent economic shocks and relatively low inflation, as during the 1990s.

IV. Concluding Remarks

This paper contributes to the evaluation of inflation targeting by assessing the merits of alternative policy rules and alternative inflation targets in a macroeconomic model. Using data for selective EU countries, the paper evaluates the performance of alternative policy rules—forward-looking and spontaneous adjustment—under alternative inflation targets of 0, 2, and 4 percent, in terms of output losses, assuming the European monetary authorities employ a loss function on deviations of output, inflation, and interest rates from their target values.

The empirical results suggest that forward-looking rules contribute to macroeconomic stability, resulting in smaller business cycle fluctuations, and increase monetary policy credibility, and that a positive inflation target, as opposed to zero

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[23] Results available on request.

[24] See Bernanke, Laubach, Mishkin, and Posen (1999), Cecchetti and Ehrmann (2000), Arestis, Caporale, and Cipollini (2002).

inflation, is superior in terms of output losses. Moreover, these results are robust to changes in the specification of the model and the time period. The same methodology applied to individual countries suggests that country-specific flexible inflation targeting may increase overall growth performance in Europe. Except in the case of Greece, the simulations suggest a negative correlation between the average output gap and the average inflation rate across the three different inflation targets both for aggregate and disaggregated data. The results also suggest a negative correlation between the output gap variance and the inflation rate variance—higher inflation targets lead to larger inflation variances and smaller output variances.

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Table 1. GMM Estimates

Coefficients:	c_1	b	k_1	k_3	ω_2	ω_1	β	J
Policy rules - inflation targets								
FLR - 0%	0.56	-0.106	0.49	0.128	0.47	0.13	0.97	[0.55]
	(3.98)*	(-4.11)*	(4.25)*	(4.52)*	(4.31)*	(4.71)*	(3.98)*	
FLR - 2%	0.57	-0.109	0.54	0.134	0.48	0.14	0.98	[0.57]
	(4.15)*	(-3.97)*	(4.18)*	(4.20)*	(4.19)*	(5.07)*	(4.39)*	
FLR - 4%	0.60	-0.107	0.57	0.137	0.55	0.15	0.97	[0.59]
	(4.71)*	(-4.28)*	(4.39)*	(3.97)*	(4.63)*	(4.19)*	(4.84)*	
SAR - 0%	0.53	-0.096	0.48	0.119	0.57	0.12	0.95	[0.43]
	(3.83)*	(-3.47)**	(4.14)*	(3.55)**	(3.86)*	(4.53)*	(4.67)*	
SAR - 2%	0.58	-0.103	0.50	0.125	0.56	0.13	0.96	[0.48]
	(4.02)*	(-3.87)*	(3.81)*	(4.19)*	(3.45)**	(4.71)*	(4.17)*	
SAR - 4%	0.57	-0.102	0.49	0.126	0.59	0.14	0.95	[0.46]
	(3.90)*	(4.03)*	(3.39)**	(4.84)*	(4.09)*	(4.22)*	(4.55)*	

Notes: Figures in parentheses denote *t*-statistics, while those in brackets denote *p*-values. FLR stands for the forward-looking policy rule, while SAR for spontaneous adjustment. The percentages next to the policy rules indicate the inflation targets—0, 2 and 4 percent. The estimations cover the period 1974:Q1 – 2001:Q4.

* significant at the 1 percent level.

** significant at the 5 percent level.

Table 2. Multivariate (IV) Estimations Under Alternative Policy Rules and Inflation Targets

Model estimations

	Sargan's test	$\bar{R}^2$
Equation (1)		
$y_t = 0.57\, y_{t-1} - 0.108\, r_t$	0.0214[0.87]	0.54
(4.29)* (-5.11)*		
instruments: constant, y_{t-2}, y_{t-3}, r_{t-1}, r_{t-2}		
Equation (2)		
$(m_t\text{-}p_t) = 0.084 + 0.59\, y_t - 0.114\, i_t$	0.0302[0.66]	0.78
(3.92)* (4.55)* (-4.64)*		
instruments: constant, $(m\text{-}p)_{t-1}$, y_{t-1}, y_{t-2}, i_{t-2}		
Equation (3)		
$\pi_t = 0.0109 + 0.53\, \pi_{t-1} + 0.41\, \pi_{t-2} + 0.131\, y_{t-1}$	0.0318[0.58]	0.76
(3.68)* (3.95)* (3.49)* (4.12)*		
instruments: constant, π_{t-3}, π_{t-4}, y_{t-2}, y_{t-3}, y_{t-4}		

Policy rules (through the first-order conditions)and inflation targets

FLR - 0%

$i_t = 3.45 + 2.13\, \pi_{t+1}^{e} + 0.28\, y_{t+1}^{e} + 0.546\, i_{t-1}$

FLR - 2%

$i_t = 3.17 + 2.08\, (\pi_{t+1}^{e} - 0.02) + 0.29\, y_{t+1}^{e} + 0.541\, i_{t-1}$

FLR - 4%

$i_t = 2.84 + 1.82\, (\pi_{t+1}^{e} - 0.04) + 0.27\, y_{t+1}^{e} + 0.546\, i_{t-1}$

SAR - 0%

$i_t = 2.80 + 1.75\, \pi_{t+1}^{e} + 0.21\, y_t + 0.558\, i_{t-1}$

SAR - 2%

$i_t = 3.00 + 1.79\, (\pi_{t+1}^{e} - 0.02) + 0.23\, y_t + 0.552\, i_{t-1}$

SAR - 4%

$i_t = 2.87 + 1.69\, (\pi_{t+1}^{e} - 0.04) + 0.24\, y_t + 0.558\, i_{t-1}$

Notes: Numbers in parentheses denote t-statistics, while numbers in brackets denote p-values. Sargan refers to the Sargan's instrument validity test. FLR stands for the forward-looking policy rule, while SAR for spontaneous adjustment. The percentages next to the policy rules indicate the inflation targets—0, 2 and 4 percent. The estimations cover the period 1974:Q1 – 2001:Q4.

* significant at the 1 percent level.

Table 3. Economic Performance of Policy Rules Under Alternative Inflation Targets
(Core Price Data; HP Filter for Output Gap)

Policy rules and inflation targets	Output		Inflation	
	Mean	Variance	Mean	Variance
Actual data	-0.6	3.66	3.2	16.23
Simulations				
FLR-0	-1.4	2.52	2.5	11.52
FLR-2	-1.1	2.31	2.8	12.47
FLR-4	-0.6	2.01	3.4	13.61
SAR-0	-1.4	3.35	3.5	12.58
SAR-2	-1.0	2.83	3.6	13.90
SAR-4	-0.7	2.28	4.2	16.09

Notes: The mean variables are expressed as a percent. FLR stands for the forward-looking policy rule, while SAR for spontaneous adjustment. The percentages next to the policy rules indicate the inflation targets—0, 2 and 4 percent. The simulations cover the period 1974:Q1 – 2001:Q4.

Table 4. Economic Performance of Policy Rules Under Alternative Inflation Targets
(Germany, France, Spain, and Greece)

Policy rules and inflation targets	Output		Inflation	
	Mean	Variance	Mean	Variance
Germany				
Actual data	-1.1	6.51	3.1	3.63
Simulations				
FLR-0	-1.6	5.48	2.3	1.82
FLR-2	-1.0	4.51	3.1	3.04
FLR-4	-0.8	4.06	3.3	3.84
SAR-0	-1.7	6.51	3.5	1.95
SAR-2	-1.4	5.29	4.2	3.31
SAR-4	-1.1	4.61	4.7	3.68
France				
Actual data	-1.2	3.98	5.7	20.72
Simulations				
FLR-0	-1.5	3.29	3.8	16.26
FLR-2	-1.1	2.53	4.3	19.08
FLR-4	-0.9	2.32	4.9	24.12
SAR-0	-1.6	4.17	4.4	20.59
SAR-2	-1.4	3.55	5.3	26.32
SAR-4	-1.1	2.48	5.8	32.09
Spain				
Actual data	-1.9	6.52	9.4	38.94
Simulations				
FLR-0	-1.1	5.69	8.1	26.39
FLR-2	-0.9	4.41	8.5	32.11
FLR-4	-0.7	4.08	9.0	36.49
SAR-0	-2.7	6.81	8.7	33.18
SAR-2	-2.2	5.75	9.6	40.23
SAR-4	-1.8	4.60	10.3	45.36

Table 4 (continued). Economic Performance of Policy Rules Under Alternative Inflation Targets
(Germany, France, Spain, and Greece)

Greece				
Actual data	-0.5	9.97	14.6	47.61
Simulations				
FLR-0	-0.7	9.22	12.4	37.19
FLR-2	-1.5	7.42	14.4	43.85
FLR-4	-1.8	6.39	17.2	48.12
SAR-0	-1.7	13.07	13.8	41.97
SAR-2	-2.2	12.24	15.5	48.53
SAR-4	-2.8	8.84	20.8	52.77

Notes: See Table 3.

Table 5. Economic Performance of Policy Rules Under Alternative Inflation Targets
(Core Price Data; SVAR Filter for Output Gap)

Policy rules and inflation targets	Output		Inflation	
	Mean	Variance	Mean	Variance
Actual data	-0.6	3.66	3.2	16.23
Simulations				
FLR-0	-1.4	3.32	2.1	10.44
FLR-2	-1.1	2.49	2.4	14.19
FLR-4	-0.6	2.12	3.1	16.02
SAR-0	-2.1	3.57	2.6	12.15
SAR-2	-1.3	2.82	3.6	14.79
SAR-4	-0.9	2.40	4.1	18.05

Notes: See Table 3.

Table 6. Economic Performance of Policy Rules Under Alternative Inflation Targets
(Core Price Data: OECD Output Gap Measures-1980-2002)

Policy rules and inflation targets	Output		Inflation	
	Mean	Variance	Mean	Variance
Actual data	-0.5	2.89	3.0	15.12
Simulations				
FLR-0	-1.2	2.62	1.3	11.03
FLR-2	-1.0	2.49	1.7	12.57
FLR-4	-0.5	2.25	3.0	14.58
SAR-0	-2.4	3.28	2.8	12.69
SAR-2	-1.5	2.79	3.4	15.21
SAR-4	-0.8	2.57	3.9	15.94

Notes: OECD measures are relative to the EU-12 group. See also Table 3.

Table 7. Economic Performance of Policy Rules Under Alternative Inflation Targets during the 1990s

Policy rules and inflation targets	Output		Inflation	
	Mean	Variance	Mean	Variance
Actual data	-0.4	2.19	2.7	13.37
Simulations				
FLR-0	-1.3	2.57	1.9	10.64
FLR-2	-1.1	2.30	2.3	12.91
FLR-4	-0.7	2.16	2.9	14.22
SAR-0	-1.8	3.51	2.3	11.32
SAR-2	-1.2	2.89	2.7	15.14
SAR-4	-0.8	2.44	3.6	16.71

Notes: The mean variables are expressed as a percent. FLR stands for the forward-looking policy rule, while SAR for spontaneous adjustment. The percentages next to the policy rules indicate the inflation targets—0, 2 and 4 percent. The simulations cover the period 1990:Q1 – 2001:Q4.