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Abstract

This paper evaluates inflation targeting and assesses its merits by comparing alternative targets in a macroeconomic model. We use European aggregate data to evaluate the performance of alternative policy rules under alternative inflation targets in terms of output losses. We employ two major alternative policy rules, forward-looking and spontaneous adjustment, and three alternative inflation targets, zero percent, two percent, and four percent inflation rates. The simulation findings suggest that forward-looking rules contributed to macroeconomic stability and increase monetary policy credibility. The superiority of a positive inflation target, in terms of output losses, emerges for the aggregate data. The same methodology, when applied to individual countries, however, suggests that country-specific flexible inflation targeting can improve employment prospects in Europe.

Journal of Economic Literature Classification: E31, E32, E37, E52

Inflation Targeting and Output Growth: Evidence from Aggregate European Data

1. Introduction

Inflation targeting (a regime that identifies price stability as the primary objective with (Svensson, 1999a) or without (King, 1997) considering output gaps), has received considerable attention in recent years.[1] A large volume of academic papers has appeared and many countries introduced such a design or monetary policy[2]. In other words, the monetary authorities commit themselves under inflation targeting to keep inflation close to an explicit target (Ruge-Murcia, 2003). New Zealand first adopted an inflation targeting policy regime. Canada, the U.K., and Australia followed. Schaechter *et al*. (2000) and Corbo *et al*. (2001) identify over 15 countries that possess experience with inflation targeting. Bernanke *et al*. (1999) and Corbo *et al*. (2001) review the experience gained with inflation targeting. The wide acceptance of the inflation targeting methodology reflects the need to avoid credibility problems from a discretionary policy (Walsh, 1995; Svensson, 1997a), and the role inflation targeting plays in setting monetary policy instruments (Bernanke and Woodford, 1997; Svensson, 1997b, 2000; Ball, 1997).

Svensson (1999a) defines two types of inflation targeting – strict and flexible inflation targeting. Strict inflation targeting implies that the monetary authorities only attempt to reduce the variability of the inflation rate around its target level. No other variable beyond the inflation variability around its target enters the monetary authorities' objective function. Flexible inflation targeting allows other variables to enter the policy makers' objective function, usually the variability of the output gap around its target of zero. In other words, flexible inflation targeting places non-zero weights on variables in addition to the variability of inflation around its target. We adopt flexible inflation targeting.

To achieve success in their targeting program, the monetary authorities must employ some policy reaction function. Such reaction functions come in many different forms, such as the Taylor (1993) rule for the interest rate. Central banks employ an interest rate instrument to implement their policies, which votes in favor of the Taylor rule. The original Taylor rule caused the nominal interest rate to respond to deviations of the inflation rate from its target level and to deviations of the output gap from zero. Taylor (1993) initially chooses parameter values for his rule so that the predicted movements in the interest rate mimicked actual movements. That is, he backed out the implied parameter values that must hold if the monetary authorities actually employed his interest rate rule, given the actual movements in the interest rate, the inflation rate, and the output gap. Since that original work, other researchers have estimated the implicit Taylor rule for different sample periods, for different precise formulations of the rule, and for different countries.

Serious criticisms of inflation targeting exist. Since monetary policy affects inflation only with a lag, the monitoring of inflation performance is a difficult task (Svensson, 1997b). Others argue that inflation targeting is suboptimal since it is better to tolerate some, albeit low, inflation than to bear the social cost associated with price stability. In other words, what is the -optimal inflation rate-?. This question relates to Howitt's Rule (Howitt, 1990) whereby the benefits from reduced inflation must offset the costs of achieving such lower inflation. Howitt concludes that the optimal target inflation rate exceeds zero, since moderate rates of inflation enhance economic welfare. That is, small positive inflation permits downward real wage movements with sticky nominal wages, a common feature of most European economies (Aiyagari, 1990; Thornton, 1996). Nevertheless, a credible monetary policy minimizes (or even eliminates) any costs associated with price stability or inflation targeting (Blinder, 1989). In addition, Cecchetti and Ehrmann (2000) and Arestis *et al*. (2002) argue that inflation targeting and inflation variability associated inversely and output variability falls far less in inflation-targeting countries.

Central banks substantially improved their credibility when under inflation targeting. This last point implies that central banks must improve their accountability, transparency and communication (Svensson, 1999b). Most relevant studies consider 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. The majority of studies demonstrate that inflation targeting does not improve inflation performance much, lower the cost of inflation, or raise the credibility of monetary authorities

(Cecchetti and Ehrmann, 2000). By contrast, Ammer and Freeman (1995), Freeman and Willis (1995), and Mishkin and Posen (1997) present evidence that inflation performance improves significantly under inflation targeting. The evidence on the effect on the sacrifice ratio is rather mixed, however. Inflation targeting performed well in New Zealand and the U.K., but not so well in Canada. In terms of credibility, inflation targeting obliges the central bank to safeguard its credibility in pursuing the inflation goal. Therefore, in inflation-targeting countries central banks possess much operational independence. Regarding credibility, the aforementioned studies show that inflation targeting does not cause long lasting effects on long-term interest rates. Kahn and Parrish (1998), however, provide contrary results for New Zealand and Canada, two inflation-targeting countries. Finally, Siklos (1999) finds mixed evidence -inflation targeting improves inflation performance in Australia, Canada, and Sweden, but does not do improve performance in Finland, New Zealand, Spain, and the U.K.

Despite the popularity of inflation targeting among policy makers, most early studies find little evidence that economic performance in non-inflation-targeting countries suffer because they did not adopt inflation targeting. More recent studies, however, unearth significant differences in the performance of the two group countries. Levin *et al.* (2004) find that inflation targeting affects the public's expectations about inflation. In an inflation-targeting regime, the target inflation rate anchors expectations about inflation (mostly at longer horizons). Therefore, inflation expectations respond less to changes in actual inflation. That outcome pays substantial benefits to the economy, since expected inflation gets negotiated into various sorts of pricing contracts, such as labor contracts. Thus, the public's expected inflation can produce a self-fulfilling outcome. As such anchoring inflation expectations anchored to target inflation keeps inflation itself low and stable. Moreover, despite some mixed empirical support for inflation targeting, many academics argue in favor of inflation targeting (Bernanke *et al.*, 1999; Alesina *et al.*, 2001). Recently, Neumann and von Hagen (2002) confirm that although inflation targeting does not clearly outperform monetary aggregate strategies, it still matters. By contrast, specific drawbacks to the adoption of inflation targeting exist. For example, an inflation-targeting regime removes the flexibility needed by policy makers to respond to changing macroeconomic conditions and unusual unexpected events.

The majority of studies on monetary rules have analyzed the impact of inflation targeting on the U.S. economy. Excluding the paper by Peersman and Smets (1999), this paper evaluates inflation targeting performance using alternative optimal interest rate rules in a simple macroeconomic model for the European Union (EU). Within the EU the European Central Bank (ECB) strategy followed is to focus on the price stability objective through a year-on-year increase of the price level below 2 percent (Issing *et al.*, 2001). This strategy has been closely followed by the ECB over the five years of its existence, gaining a high level of credibility (Issing, 2004).

The primary question that this study seeks to answer is whether a zero or a positive inflation target is desirable. In particular, it is recognized that over the sample period there was not in place any convergence of policies to achieve the EMU. Moreover, one may argue that finding a positive inflation target 'better' may merely reflect the fact that the average inflation rate over this period was closer to 4% than it was to 2% or 0%.[3] What merely this study does is to inquire how EU's economic performance would have changed if various inflation targets had been adopted. Thus, the approach is to think through three hypothetical scenarios of inflation targeting by the EU countries and use the thought exercise to gain a better understanding of the output gains. Although inflation targeting offers greater credibility to the European monetary authorities let us not forget that the euro area countries have already a high degree of credibility. Therefore, the results will be very fruitful if they support that those countries incur a cost of a loss of output against the benefit of higher credibility in their fight to inflation. The additional merit of this study is that for the first time it employs European aggregate data in order to evaluate the aforementioned alternative inflation targets. Although the analysis is novel in the above respects, in most other ways it is entirely conventional. It makes use of standard and popular monetary policy rules, i.e. forward looking rules, while it uses standard econometric techniques, i.e. instrumental variables as well as simulation results.

The remainder of the paper is organized as follows: Section 2 presents the specification of an open macro model, while Section 3 presents and discusses the empirical analysis. Finally, concluding comments are presented in Section 4.

2. The Model

2.1 The benchmark model

We adopt a version of the IS-LM-AS model proposed by Clarida *et al.* (1999), McCallum and Nelson (1999), Woodford (2000), and Clifton *et al.* (2001). The first equation describes the IS curve through which the behavior of output is dominated by movements of 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 i.i.d. random variable with zero mean and variance $\sigma_{\lambda 1}{}^2$. Theoretically, the negative b reflects intertemporal substitution of consumption. According to equation (1), interest rates influence aggregate demand through consumption as well as investment. Finally, lagged output, indicating persistence effects, affects current output (Fuhrer, 1996).

The second equation describes the LM curve (Haldane and Salmon, 1995):

$$m_t - p_t = c_0 + c_1\, y_t + c_2\, i_t + v_t, \quad c_1 > 0,\ c_2 < 0 \tag{2}$$

where v equals a monetary disturbance term.

The third equation captures an augmented Phillips curve as follows:

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

where π denotes inflation, π^e denotes expected inflation, and θ denotes a real disturbance term (cost-push shock, Svensson, 2000) that obeys $\theta_t = \nu\theta_{t-1} + \lambda_{2t}$, with $0 \leq \nu \leq 1$ and λ_{2t} is an i.i.d. random variable with zero mean and variance $\sigma_{\lambda 2}{}^2$. Equation (3) describes a traditional expectations augmented Phillips curve (Blanchard, 1997). Inflation is affected by expected inflation at t+1. Moreover, persistence effects exist, since lagged inflation enters explicitly in equation (3) (Fuhrer, 1996; Clarida *et al.*, 1999).

The fourth equation describes the formation of expectations:

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

where η is a random term. Equation (4) yields after recursive substitution:

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

According to (4a), expected inflation reflects past values of inflation (backward-looking expectations). Of course, the sum of g_i coefficients must fall below one in absolute value for stability. Equations (3) and (4a), in turn, imply that inflation depends entirely on past values of inflation and the output gap.[4]

Policy rules

To evaluate the case of inflation targeting, we introduce explicit policy rules. The monetary authorities affect the inflation rate through a policy instrument, a short-term nominal interest rate. This last hypothesis comes against the usual assumption that the monetary authorities choose directly the inflation rate after observing the random shocks (Ruge-Murcia, 2003). Svensson (1999b, 2003) argues that a rule is nothing more than a commitment by a central bank to adjust its policy instrument as necessary to ensure that at a particular point of time the economy's future evolution satisfies a certain targeting criterion, e.g. inflation. Moreover, Taylor (2000) argues that a rule is not a mathematical economic expression used in a mechanical fashion, but it is used as a benchmark guideline through which sometimes a certain degree of discretion seems to be crucial.

Within a regime of inflation targeting a critical question focuses on whether a point target or a range around a point target is the most desirable. Usually, the difficulty in forecasting future inflation as well as the paucity of successful predictions about the effects of monetary policy on inflation has suggested the adoption of a range around the target (Longworth and Freedman, 2000). The wider the range is, the higher the likelihood that the monetary authorities keep inflation within the range and the lower the likelihood of altering inflationary expectations and economic behavior is in the long run. For empirical purposes, we use three different inflation targets, i.e. 0, 2, and 4 percent. In addition, we also assume that the monetary authorities raise the interest rate whenever the actual inflation in the previous period exceeds target inflation.

We use the model described by equations (1) through (3) to compare the performance of the above policy rules. We adopt a standard loss function, where the central bank dislikes high inflation rate, large output gaps, and large interest rate fluctuations. Therefore, following Woodford (2003) and McCallum and Nelson (2004), the central bank's loss function (described by a symmetric quadratic parameterization functional form) at time t equals:

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

where, i_t is the central bank's policy rate, E is the expectation operator, ω_1 and ω_2 are positive parameters (less, but not equal, than 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 level fluctuations.

The policymaker minimizes the loss function subject to model described by equations (1) through (3) (as in Clarida et *al.*, 1999; Peersman and Smets, 1999; Svensson, 1999c). By solving the policymakers' optimization problem and through the first order conditions we get a non-linear rule, which responds to the developments in the economy. The first order conditions are:

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

then we can solve for the reaction function instrument and get:

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

This study also used two major alternative policy rules,[4] a forward looking rule (FLR) (Henderson and Mckibbon, 1993; Clarida *et al.* 1999) and the spontaneous adjustment rule (SAR) (Clarida *et al*. 1999)[5]. According to this set-up, the SAR rule indicates that inflation targeting takes into consideration output changes and changes in expected inflation. Both rules include a lagged interest rate term, whose interpretation is in terms of interest rate smoothing. According to Levin *et al.* (1999), rules that incorporate interest rate smoothing and respond to output gap changes as well as to deviations of inflation from its target perform relatively well. Moreover, Blinder (1999) argues that interest rate smoothing has received widespread practice in central banking, since central banks are potentially reluctant to change short-term interest rates by much as this leads to substantial variations in the prices of outstanding debts. Goodfriend and King (1997) and Jensen (2002) argue that forward-looking behavior really matters in private agent's decisions. Moreover, the superiority of the forward-looking type of rules lies on the fact that it captures forward-looking behavior on the part of the central bank (Clarida *et al*. 2000). The two alternative policy rules considered are as follows:

$i_t = a_5 + a_6 (E_t\pi_{t+1} - \pi^*) + a_7 E_t y_{t+1} + a_8 i_{t-1}$ forward looking (5)

$i_t = a_9 + a_{10} (E_t\pi_{t+1} - \pi^*) + a_{11} y_t + a_{12} i_{t-1}$ spontaneous adjustment (6)

According to those 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). The rules (5) and (6) provide benchmarks for evaluating actual inflation and output performance with "optimal" performance in the euro area.

III. Empirical Analysis

Data

Quarterly observations on real output (Y) measured by GDP at 1995 prices, core prices (CP) measured by core harmonized CPI and defined as the overall index excluding energy and food, the interbanking nominal interest rate (i), the money supply (M) measured as M1, and unemployment (u) measured as the unemployment percentage rate were obtained from various issues of the OECD Main Economic Indicators CD-Rom over the period 1974-2001. The sample includes the following European countries: Germany, France, Belgium, the Netherlands, the United Kingdom, Italy, Luxemburg, Spain, Portugal, Denmark, Austria, Finland, Sweden, Finland, and Greece. Some countries in the sample performed under inflation targeting even before the euro era, i.e. Finland, Spain, Sweden, and the United Kingdom. For empirical purposes, the output gap was estimated as a residual variable through the Hodrick-Prescott (HP) filter with smoothing parameter=1,600 (Hodrick and Prescott, 1981).

The relevant variables at the European level are constructed using a weighting and aggregation system proposed by Maulon and Sarda (1999). According to this method, we convert all national variables into a chosen currency (i.e. the euro). The method requires the selection of the appropriate exchange rate. We employ the Purchasing Power Parity (PPP) exchange rate in our calculations.

Inflation is measured as the differences in logarithmic prices and the real interest rate, (r), equals the nominal interest rate minus expected inflation (i.e., the Fisher interest rate equation). Equation (4a) suggests using the Box and Jenkins technique for the estimation of expected inflation. That analysis suggests that European inflation follows an ARMA(2, 0) model over the period under investigation (within-the-sample-forecasting). That model generates our expected inflation rate series. In addition, Box and Jenkins analysis recommends an ARMA(1, 0) model that generates within-the-sample forecasting values for expected output (to be used in the estimation of the first-order condition out of the optimization problem).

Although most countries target the CPI (Roger and Stone, 2004), core inflation targets play key roles in policy formulation. Core inflation measures remove volatile components from the overall price index, such as food and energy items. Bryan and Cecchetti (1994) and Roger (1997) recommend such price data so that policy makers can set credible inflation target bands in the process of a successful monetary policy.[6] Folkertsma and Hubrich (2001) demonstrate that overall price indices reflect every shock impinging on the economy, which turns the implementation of an efficient inflation monetary policy into a nightmare for the central banks. Cogley and Sargent (2000) and Cecchetti and Wynne (2003) also support the idea of a core index for monetary policy strategy within the ECB (i.e., adjusting short-term interest rates so that inflation converges to its target in the long run). Moreover, Vega and Wynne (2003) argue that a core index provides comparability across all EU members, while Breuss (2002) also argues that monetary policy should orient towards core inflation in the Euroland, since the exclusion of such volatile items as energy and food lowers the volatility of inflation itself, resulting in lower interest rates and, therefore, higher income outcomes. Finally, Bagliano *et al*. (2002) argue that core inflation data proves more important, since such data are constructed through a forward-looking method. Throughout the paper lower case letters denote variables expressed in logarithms, while all estimates and tests were derived using the econometric software of RATS, version 4.2, and that of MicroFit, version 5.1.

Comparative output and inflation results: euro area data

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). The estimation of the model (1) through (3) gives the estimates of certain parameters, which are very close to their counterparts estimated through GMM. From GMM estimates we will use the parameters involved in the interest rate rule. Three lags of the short-term interest rate (in a stationary form), inflation, and output gap are included as instruments. According to Davidson and MacKinnon (1993), in small samples efficiency gains from using more instruments are obtained at the cost of a greater bias in the estimates. Thus, the number of instruments was chosen to ensure parameter identification while minimizing the bias. Moreover, as a quantitative definition of inflation targeting, we impose the three alternative inflation targets, i.e. 0 per cent, 2 per cent, and 4 per cent under the three alternative rules, i.e., backward, forward, and spontaneous. The J-statistic, which is asymptotically distributed as a $\chi^2_{\text{M-K}}$ distribution with M being the number of instruments and K the number of parameters to be estimated, displays that the null hypothesis of valid over-identifying restrictions is never rejected. In other words, the model seems to perform relatively well.

Table 2 reports the estimated model. In particular, it reports the estimation of equations (1) through (3) with the SURE methodology over the sample period. All variables (except the output gap and inflation) have been measured as log-deviations (except interest rates) from their steady-state values (unit root tests are available upon request). The coefficients in equation (1) to (3) behave as expected from theory. Sargan's instrument validity tests indicate that the chosen instruments are independent of the error term. The estimated model was used to generate artificial values for the output gap and inflation in terms of mean and variances.

The results, reported in Table 2 suggest that both rules are a satisfactory description of policy. In particular, the coefficients on output gap as well as on inflation are statistically significant and show the correct sign. The smoothing interest rate coefficient is ranging from 0.541 to 0.558, suggesting a high degree of interest rate smoothing. It is also worth mentioning that the rules indicate that the current inflation or expected inflation coefficients are statistically significant and above unity, implying that in the face of inflation, central banks raise interest rates enough to keep the real rate constant and, thus, to curb inflationary pressures.

Following the estimation of the model (1) through (3), we incorporate the rules built with the assistance of the GMM estimations and then we generate artificial 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. We employ a zero-, a two-, and a four-percent target inflation rates. The counterfactual experiments address the following question: How would the output gap and the inflation rate have evolved over the sample period, if the monetary policy makers had followed each of the two optimal policy rules throughout that period?

Several interesting results emerge. First, a negative trade-off exists between the mean output gap and the mean inflation rate as well as between the output-gap and inflation-rate variances. That 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 appears frequent in the literature (Fuhrer, 1997). Ball (1997) and Bean (1998) argue that the monetary authorities find it extremely difficult to satisfy simultaneously both their output-gap and inflation-rate targets, since the economy continuously experiences various supply and demand shocks. Therefore, the authorities must decide how fast to correct any divergence of the inflation rate from its target (i.e., achieve as low a variance of inflation around its target at the expense of a higher output gap variance or maintain a low output variance and accept a higher inflation-rate variance around its target). In other words, the monetary authorities reach optimal decisions through a trade-off between the volatilities of the two variables under investigation. Such a policy menu represents an optimal policy frontier, given the relative weighting of these two variables in the loss function.

Second, the optimal policy rules suggest that the forward-looking rule dominates in most respects the other rule. The forward-looking rule exhibits higher mean output, lower mean inflation, lower output-gap variance, and lower inflation variance than the alternative rule. The importance of forward-looking expectations becomes substantial in successful policy implementation, which favorably affects the credibility of the monetary authorities (i.e., the ECB). Moreover, Batini and Haldane (1998) and Amano *et al*. (1999) also show that forward-looking rules prove more efficient, in terms of lower mean and variable inflation. The results in Table 3 support those arguments.

Robustness analysis: Country data instead of euro area data

This section examines the robustness of the results after disaggregating to the country level. In particular, we apply the same method to Germany, France, Spain and Greece. In each case, we reestimate the macroeconometric model, equations (1) through (3) (the results are available upon request).

Table 4 reports the output gap and inflation results. They show that the findings at the aggregate level generally remain valid for three out of the four countries under investigation (i.e., Germany, France and Spain). Greece, however, exhibits different results. In particular, the mean output gap and the mean inflation rate correlate positively, unlike the negative correlation for the aggregate results.

If we accept the conclusions of Akerlof *et al*. (2000) (i.e., unemployment remains below the natural rate only if inflation rates are kept (moderately) above zero), then our 4% inflation targeting for Germany, France and Spain could lubricate their economies through the flexibility of real wages, resulting in a lower, more stable, output gap (see also, Wyplosz, 2001). In contrast, a higher inflation-targeting regime seems inappropriate for the Greek economy as it also increases output-gap. To some extent, our empirical findings converge on Svensson's (1999b) conclusions that higher 'flexible' inflation targeting for certain European economies will gradually stabilize output and unemployment, while inflation variability should fall below the case of 'strict' inflation targeting (current policy). In Greece public investments can sustain growth. Public spending and growing deficits shift the aggregate demand and produce higher inflation and inflation expectations, which is a destabilizing process. In such a perverse situation, Greece must closely watch labor productivity and unit labor costs. Nevertheless, since Greece is a relatively closed economy in the euro area, only a 'strict' low inflation targeting with frequent intervention of monetary authorities can stabilize the output gap against aggregate demand and aggregate supply shocks.

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 (Ball, 1997; Clarida *et al*. 1999; Orphanides, 1999; Rudebusch, 1999; Svenson and Woodford 2000; Camba-Mendez and Rodriguez-Palenzuela, 2003). To test the robustness of our results we use an alternative method of estimating the output gap. In particular, we adopt a multivariate time-series model. Following the method of 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. We employ a structural vector autoregressive (SVAR) model with certain long-run restrictions. In particular, inflation only responds to its own structural shocks, real output only responds to its own and inflation shocks, while unemployment responds to three shocks simultaneously. After estimating the three-variable system (results available on request) and getting the new detrended output gap data, we repeat our analysis and Table 5 reports the results. They nearly match those reached in Table 3.

In addition to VAR-constructed gap measures, it is useful to use 'off-the-shelf' measures, e.g. OECD output gaps. After obtaining those measures for the Europe-12 group from the OECD Main Economic Indicators CD-ROM and over the period 1980-2002, the results are reported in Table 6. They do not point any differences to those reached before (Table 5). An inflation target away from zero seems to be the appropriate policy followed, since it exhibits superiority, in terms of lower output gaps.

Robustness analysis: An alternative sample period-The 1990s

Inflation in Europe was much higher in the past, especially in the 1970s and 1980s. As such, reasonable inflation targets for today may produce unreasonable targets for the past. Also, the variation of inflation across European countries fell dramatically in recent years. Some even argue that cyclical fluctuations in the 1990s were smaller than those in the 1980s (Bernanke *et al*., 1999; Cecchetti and Ehrmann, 2000; Arestis *et al*., 2002). Thus, it is difficult to determine whether lower fluctuations reflect inflation targeting or more favorable shocks. We address this concern by reestimating and simulating the model only during the 1990s. In particular, we estimated equations (1) through (3) from 1990:1 through 2001:4 and then we generated in-sample forecasting values. Table 7 reports the results. They are consistent with an inflation target away from zero that seems to be a successful regime choice, in terms of lower output gaps. In addition, the average output gap and the average inflation rate for the simulated performance are lower in the 1990s than in the full sample findings, implying that the implementation of monetary policy under inflation targeting still receives favorable support even within an environment with less frequent economic shocks.

IV. Concluding Remarks

Our paper contributes to the assessment of inflation targeting by assessing the merits of alternative policy rules and alternative inflation targets in a macroeconometric model. Our study uses for the first time European aggregate data to evaluate the performance of these alternative policy rules and alternative inflation targets where the European monetary authorities employ a loss function on deviations of output, inflation, and interest rates from their target values.

Two specific policy rules were tested, a forward-looking rule and a spontaneous-adjustment rule. The empirical findings indicated that forward-looking rules contributed significantly to macroeconomic stability, resulting in lower business cycle fluctuations and increased monetary policy credibility. Three alternative inflation targets were tested, i.e. a zero percent, a two percent, and a four percent inflation rate. Except in the case of Greece, we find 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. Higher inflation targets lead to lower average output gaps and higher average inflation. At the same time, the counterfactual experiments indicate a negative correlation between the output-gap variance and the inflation-rate variance across the three different inflation targets. Higher inflation targets lead to higher inflation-rate variances and lower output-gap variances. For Greece, we find a positive correlation between the average output gap and the average inflation rate. But the negative correlation between the output-gap variance and the inflation-rate variance continues to hold.

As an agenda of future research, the authors plan to extend the policy rule analysis by incorporating exchange rate as well as financial variables, since inflation targeting acts as a pre-requisite for strengthening financial markets and through them the real economy. The central banks that implement an inflation targeting strategy think primarily of reducing the distortions on financial markets caused by monetary policy.

NOTES

1. Since monetary and fiscal policy affect aggregate demand, policies designed to stabilize inflation (price level) will automatically stabilize real GDP when the economy only faces aggregate demand shocks. If, however, the economy primarily experiences aggregate supply shocks, then stabilizing inflation (price level) will increase the variability of real output.
2. Price stability was Friedman's suggestion. The control of the price level was Keynes's concern through certain guidelines, albeit the control was not proved to be very successful. However, as variation in aggregate demand cases the GDP volatility, price stability cannot be maintained without losses in output and employment since markets are ripped off their dynamism. Producers cannot respond to increased demand unless they are caught by surprise that reinforces their tentative motivation.
3. Akerlof *et al*. (1996, 2000) emphasize that some inflation lubricates the economy and allows for more flexible adjustments in real wages. Wyplosz (2001) also argues that the European Central Bank by announcing low inflation targets (e.g. 2 percent) increases rigidities in the economy and thus leads to higher structural unemployment. In contrast, Issing (2001) argues that low inflation contributes to the elimination of money illusion, which, in turn, lessens the need for positive inflation rates to 'lubricate' the system. Furthermore, low inflation targets also expose the economy to the risk that inflation may drop below 0 percent, a dangerous situation that can push the economy into a deflationary spiral.
4. According to Peersman and Smets (1999), the external transmission channel (the exchange rate between the dollar and the DM) does not appear to be significant. Although this could raise some serious criticisms, we consider that the euro area functions as a relatively closed economy.
5. We use simple rules that ignore a large amount of information about the economy, such as variables representing, labor and financial markets, for example. The benefit of

a simple rule comes from the parsimony in the specification but the cost emerges because of the inability to take advantage of this information. Levin *et al*. (1999), Dennis (2002), and Levin and Williams (2003) find that only small improvements in performance exist from moving to more-complicated rules. By contrast, Finan and Tetlow (1999) reach the opposite result.

6. Others recommend alternative and more sophisticated measures of inflation for an inflation targeting monetary policy regime, such as trimmed mean indices (Bryan and Cecchetti, 1994; *Bryan et al.*, 1999). The lack of such data for all members of the Euroland requires our analysis to be based on original core price index data.

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Table 1. GMM estimates

Coefficients:	c_1	b	k_1	k_3	ω_2	ω_1	β	J
Rules-Targets								
Forward-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)*	
Forward-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)*	
Forward-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)*	
Spontaneous-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)*	
Spontaneous-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)*	
Spontaneous-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.
* 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)		
$(m_t - p_t) = 0.084 + 0.59\, y_t - 0.114\, i_t$	0.0302[0.66]	0.78
(3.92)* (4.55)* (-4.64)*		
instruments: constant, $(m-p)_{t-1}$, 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}		

Rules (through the first order conditions)

Forward-0%

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

Forward-2%

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

Forward-4%

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

Spontaneous-0%

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

Spontaneous-2%

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

Spontaneous-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.

* 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)

Rule	Output		Inflation	
	Mean	Variance	Mean	Variance
Actual data	-0.6	3.66	3.2	16.23
Artificial data				
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 simulation covers the period 1974:1 – 2001:4. The mean variables are expressed as a percent. The suffixes 0, 2, and 4 after the acronyms of FLR, and SAR indicate the percent inflation-rate target (i.e., 0 percent, 2 percent, and 4 percent).

Table 4. Economic performance of policy rules under alternative inflation targets (Germany, France, Spain and Greece)

Rule	Output		Inflation	
	Mean	Variance	Mean	Variance
Germany				
Actual data	-1.1	6.51	3.1	3.63
Artificial data				
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
Artificial data				
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
Artificial data				
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

Greece				
Actual data	-0.5	9.97	14.6	47.61
Artificial data				
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)

Rule	Output		Inflation	
	Mean	Variance	Mean	Variance
Actual data	-0.6	3.66	3.2	16.23
Artificial data				
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)

Rule	Output		Inflation	
	Mean	Variance	Mean	Variance
Actual data	-0.5	2.89	3.0	15.12
Artificial data				
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 (the 1990s-core inflation-HP filter for output gap)

Rule	Output		Inflation	
	Mean	Variance	Mean	Variance
Actual data	-0.4	2.19	2.7	13.37
Artificial data				
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: See Table 3.