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HOW DOES THE ECB TARGET INFLATION?

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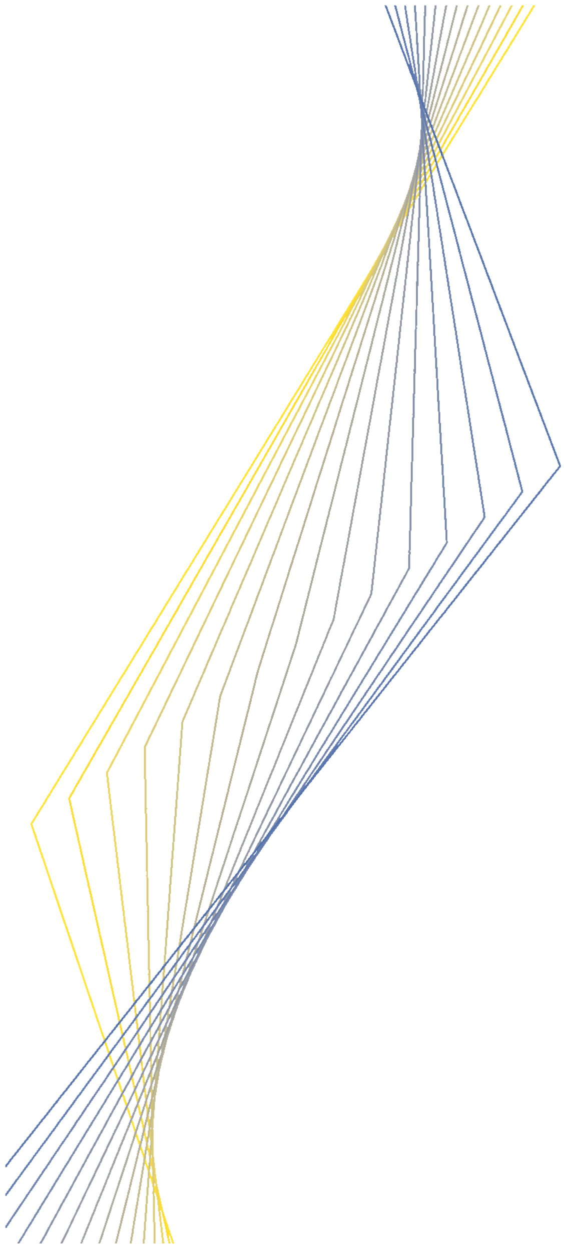

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BY PAOLO SURICO[2]

May 2003

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Abstract

The announced primary objective of the European Central Bank is price stability. While no restrictive reference is given to how the goal should be reached, such a mandate can be thought as a concern to stabilize some relevant macroeconomic aggregates. Accordingly, we frame ECB monetary policy in a general set up that allows policy makers to weight differently positive and negative deviations of inflation and output gaps. The empirical analysis on aggregated Euro area data indicates that ECB monetary policy can be characterized by a nonlinear policy rule. While the objective of price stability is symmetric, the one on real activity is not in that output contractions require larger policy responses. Moreover, the actual Euro interest rate highly commoves with the counterfactual rate that the Bundesbank would have followed if charged to set policy rates for the Euro area.

JEL Classification: E52, E58.

Keywords: ECB monetary policy rule, (asymmetric) central bank policy preferences, Bundesbank counterfactual interest rate target

Non-technical summary

In this paper, we study the first years of the Euro area monetary policy through the identification of the preference parameters in the ECB objective function. To this end, we develop a method to recover the structural parameters of the monetary authorities from the estimates of the *targeting rule*, which is the first order condition that solves the optimization problem relevant to the central bank. As the proposed model generalizes the conventional linear-quadratic framework, the targeting rule turns out to be potentially *nonlinear*, with asymmetric preferences and a convex aggregate supply curve being the sources of nonlinearity.

Preferences are asymmetric in the sense that decision makers are allowed, but not required, to weight differently positive and negative deviations of inflation and output gaps, and this is motivated by a recent empirical literature on some G7 economies. The aggregate supply curve is convex in that its slope varies with the level of capital utilization, and it is introduced to account for several recent contributions on the Euro area using aggregated data. It should be noted that while both types of nonlinearity may prove to be empirically relevant, neither asymmetric preferences nor a convex supply curve are imposed in the model. Rather, they are nested in a general specification that recovers the linear-quadratic set up for some limiting case of parameter values. This implies that potential evidence of nonlinearities in the central bank first order condition can be disentangled, tested and reverse engineered into its relevant source(s).

While the available observations do not allow any way out of the small sample size, we discuss below the extent to which our estimates provide a useful preliminary evaluation of how the ECB conducts monetary policy. The main results using monthly Euro area aggregated data over the period 1997:7-2002:10 can be summarized as follows. First, there is no evidence of asymmetric responses to movements in inflation since the ECB appears to be concerned about risks of deflation as well inflation. Second, output contractions of a given amount bring about a more vigorous policy response than output expansions of the same magnitude, consistently with an asymmetric objective. Third, the observed path of the Euro policy rate highly commoves with the counterfactual targets implied by the estimates of the Bundesbank and the Fed reaction functions, given the historical Euro area measures of inflation and output gaps. However, unlike the Bundesbank, the Fed-type of behavior would require a substantially more aggressive policy stance.

1 Introduction

The first four years of the EMU can be described as a period of low and stable inflation. Despite a fairly smooth path, price changes have been persistently above the threshold value of 2%, being however still consistent with a quantitative definition of price stability over the medium-term. The left-top panel of Figure 1 shows that after some encouraging initial records, HICP inflation has overcome the threshold in April 2000 without crossing it back afterwards. However, the frequent reversals observed in the second half of the sample suggests that the primary objective of price stability has been successfully pursued such as to legitimate a larger concern to some secondary objectives.

In the introductory statement to the ECB press conference on 8 April 1999, Willem Duisenberg makes the argument clear by stating '*the present situation and the prospects for the increase in the rate of inflation are such that they seem, for as far as we can look forward, also to remain well below that ceiling of 2%. So, inflation is not a danger, which enabled us to pay more attention to the second area of objectives of the European Central Bank - that is to support the general economic policies of the European Community*'. Such a concern reemerges in another introductory statement on 8 November 2001 when he reasons '*the maintenance of price stability remains our first priority. [...] today's (cut of 50 point basis) could be taken "without prejudice to price stability", and it thereby supported the other goals of EMU, such as economic growth*'.

These statements do not come as a surprise if one considers that in an era of inflation stability, output developments may actually be a better leading indicator for inflation than inflation itself. Then, monitoring the business cycle would be a successful strategy to preemptively avoid any inflation scare. However, given the pervasive downward risks that appear to characterize the recent history of Euro area economic activities, the monetary authorities may face an incentive to develop a greater precautionary demand for output expansions than for low inflation in an effort to escape recessions and realize better policy outcomes.

A simple modeling device to frame monetary policy making is to regard policy interventions as the solution of an intertemporal optimization problem according to which the central bank minimizes some quadratic criterion under the constraints provided by the structure of the economy. The quadratic characteristic of the objective and the linear feature of the constraints give rise to a *linear* first order condition whose reduced-form parameters can only be interpreted as convolutions of policy makers' preferences and the behavioral parameters of the economy (see Dennis, 2002, and Favero and Rovelli, 2003). To the extent that policy objectives identify policy regimes, modelling and recovering the preferences of the central bank then becomes crucial in evaluating the performance of the monetary authorities.

This paper contributes to the literature on monetary policy rules by developing a novel identification scheme for policy makers' preferences. The latter requires the estimation of the *targeting rule*, which is the first order condition that solves the optimization problem relevant to the central bank. As the proposed model generalizes the conventional linear-quadratic framework, the targeting rule turns out to be potentially *nonlinear*, with asymmetric preferences and a convex aggregate supply curve being the sources of nonlinearity.

Preferences are asymmetric in the sense that decision makers are allowed, but not required, to weight differently positive and negative deviations of inflation and output gaps, and this is motivated by a recent empirical literature on some G7 economies (see Bec, Salem and Colard, 2002, Cukierman and Muscatelli, 2002, Ruge-Murcia, 2003, and Surico, 2002, among others). The aggregate supply curve is convex in that its slope varies with the level of capital utilization, and it is introduced to account for the evidence on aggregated Euro area data reported by Peersman and Smets (2002), and Dolado, Maria-Dolores and Naveira (2003). It should be noted that while both types of nonlinearity may prove to be empirically relevant, neither asymmetric preferences nor a convex supply curve are imposed in the model. Rather, they are nested in a fairly general specification that recovers the linear-quadratic set up for some limiting case of parameter values. This implies that potential evidence of nonlinearities in the central bank first order condition can be disentangled, tested and reverse engineered into its relevant source(s).

The empirical analysis must acknowledge the short time length of the sample that spans a period of five years. While the available observations do not allow any way out of the issue, we discuss below the extent to which our estimates provide a useful preliminary evaluation of how the ECB conducts monetary policy. The main results using monthly Euro area aggregated data over the period 1997:7-2002:10 can be summarized as follows. First, there is no evidence of asymmetric responses to movements in inflation. In the words of the Chief Economist Otmar Issing (2002b), "*the definition of price stability is symmetric in the sense that the ECB is concerned about risks of deflation as well inflation. [...The former] can be substantially reduced by avoiding that inflation falls below some safety margin*". Second, output contractions of a given amount bring about a more vigorous policy response than output expansions of the same magnitude, consistently with an asymmetric objective. Third, the observed path of the Euro policy rate highly commoves with the counterfactual targets implied by the estimates of the Bundesbank and the Fed reaction functions, given the historical Euro area measures of inflation and output gaps. However, unlike the Bundesbank, the Fed-type of behavior would require a substantially more aggressive policy stance. Fourth, adding a monetary aggregate to both the policy objectives and the structure of the economy suggests that the M3 growth rate is regarded as a leading indicator for future inflation rather than as a target per sè in that it enters as an argument of the policy rule but not as an argument of the objective function.

The paper is organized as follows. Section 2 sets up the model, introduces nonlinearity and solves for the central bank optimal control problem. Section 3 derives its empirical version and shows how asymmetric preferences and a convex aggregate supply can be independently identified. The following part reports the estimates for the ECB, the Bundesbank and the Fed, and perform the counterfactual experiment for the Euro area. Section 5 concludes.

2 The model

We assume that the central bank conducts monetary policy through a *targeting rule* according to the terminology of Svensson (1999). Thus, all available information is used at each point in time to bring the target variables in line with their targets by penalizing any future deviation of the former from the latter.

In a recent public speech as Governor of the Fed, Bernanke (2003) argues that the actual practice of the US Federal Reserve and many of the major central banks around the world is better described as *constrained discretion.* The latter is defined by two simple and parsimonious principles that bring together some basic features of discretion and rules. First, the central bank must establish a strong commitment to keeping inflation low and stable. Second, subject to the condition that the first principle is satisfied, monetary policy should strive to limit cyclical swings in resource utilization. To the extent that these principles do also inspire the conduct of monetary policy in the Euro area, the assumption of a *targeting rule* can be viewed as a good first approximation of the operating procedure of the ECB.

The policy rule is modeled as the outcome of an intertemporal optimization problem in which decision makers minimize a given criterion under the constraints provided by the structure of the economy. The optimizing device allows us to reverse engineer the objectives of the monetary authorities, which are unobservable, from the observed path of policy rates implying that evidence on the latter can be interpreted as informative for the former. Since our identification strategy relies on the estimation of a model-based specification for the reaction function, we challenge the assumption of symmetric policy preferences in the context of a popular framework for monetary policy analysis. This is a version of the New-Keynesian model of the business cycle derived in Yun (1996), and Woodford (2003, Ch. 3 and 4), among others.

2.1 The structure of the economy

This subsection describes an augmented version of the New-Keynesian sticky prices forward-looking model in which the Phillips curve is specified as a potentially convex relation. While not microfounded, such a generalization is designed to control for an alternative source of non-linearity such that the estimation of a reduced-form policy rule can unambiguously identify asymmetric preferences. We will return to this issue in the empirical section. The evolution of the state variables is compactly represented by the following two-equation system corresponding to an aggregate supply and to an aggregate demand relation, respectively:

$$\pi_t = \theta E_t \pi_{t+1} + \frac{k y_t}{1 - k\tau y_t} + \varepsilon_t^s \tag{1}$$

$$y_t = E_t y_{t+1} - \varphi \left(i_t - E_t \pi_{t+1} \right) + \varepsilon_t^d \tag{2}$$

Equation (1) captures in a log-linear fashion the staggered feature of a Calvo-type world (1983) in which each firm adjusts its price with a constant probability in any given period, and independently of the time elapsed from the last adjustment. The discrete nature of price setting creates an incentive to adjust prices by more the higher is the future inflation expected at time t. The inflation level is π_t whereas the output gap is denoted by y_t and captures the movements in marginal costs associated with variations in excess demand. Equation (2) is a log-linearized version of a standard Euler equation for consumption combined with the relevant market clearing condition. It basically brings the notion of consumption smoothing into an aggregate demand formulation by making output gap a positive function of its expected future value and a negative function of the real interest rate, $i_t - E_t \pi_{t+1}$. Lastly, ε_t^s and ε_t^d are respectively cost and demand disturbances that obey a zero mean-reverting process.

The parameter τ governs any potential nonlinearity in the structure of the economy as it allows the slope of the aggregate supply curve to be steeper at a higher level of inflation and output gap (see Schaling, 1999). This implies that movements in the aggregate demand associated to a monetary policy change like an interest rate increase generate a stronger (weaker) effect on output and a weaker (stronger) effect on inflation when output is low (high). As argued by Peersman and Smets (2003), this can be rationalized by the presence of either a capacity constraint or some menu costs. Downward wage rigidity and the existence of money illusion at very low rates of inflation may also account for such a convexity. Nevertheless, linearity is recovered for $\tau = 0$.

As shown by Galì and Gertler (1999), and Galì, Gertler and Lopez-Salido (2001 and 2003), the New-Keynesian forward-looking Phillips curve provides a good first approximation to the dynamics of US and Euro area inflation. Empirical support for a pure forward-looking aggregate supply relation can also be found in Ireland (2001) for the US and in Benigno and Lopez-Salido (2002) for Germany. Smets and Wouters (2002) estimate an hybrid version of the aggregate supply for the Euro area with Bayesian methods and find a highly dominant forward-looking component in spite of a large prior in favor of a backward looking specification.

2.2 A general specification of the policy objectives

An important aspect of monetary policy making in such a model is that policy actions are taken before the realization of economic shocks and therefore before the state variables are determined. Accordingly, the central bank objective is to choose a path for interest rates at the beginning of period t conditional upon the information available at the end of the previous period. This timing device is captured by the following intertemporal criterion:

$$\underset{\{i_t\}}{Min} \quad E_{t-1} \sum_{\tau=0}^{\infty} \delta^{\tau} L_{t+\tau} \tag{3}$$

where δ is the discount factor and L stands for the period loss function. Our framework differs from the conventional quadratic set up as we employ a more general specification of the monetary authorities' objectives. Indeed, the quadratic form may approximate reasonably well a number of different functions and in the absence of a rigorous theoretical foundation any specific nonquadratic proposal is destined to be unsatisfactory against the wide range of plausible alternatives. Hence, rather than attempting to uncover the correct functional form of policy makers' preferences, we evaluate the symmetric quadratic paradigm upon the empirical merits of the monetary policy rule that this specification implies. With this descriptive scope in mind, we write L_t as follows:

$$L_t = \frac{e^{\alpha(\pi - \pi^*)} - \alpha(\pi_t - \pi^*) - 1}{\alpha^2} + \lambda \left[\frac{e^{(\gamma y_t)} - \gamma(y_t) - 1}{\gamma^2} \right] + \frac{\mu}{2}(i_t - i^*)^2 \tag{4}$$

The coefficients λ and μ represent the central bank's aversion to output fluctuations around potential and to interest rate *level* fluctuations around the target i^*. The policy preference towards inflation stabilization is normalized to one and therefore λ and μ are expressed in relative terms. The inflation target is π^* whereas the parameters α and γ capture any asymmetry in the objective function of the monetary authorities.

The linex specification in (4), which has been originally proposed by Varian (1974) and Zellner (1986) in the context of Bayesian econometric analysis and introduced by Nobay and Peel (1998) in the optimal monetary policy literature, embodies a number of appealing characteristics. First, it allows for departures from the quadratic objective in that policy makers may treat differently positive and negative deviations of the target variables from the reference values. This pattern is shown in Figure 2 which plots the standard quadratic versus the asymmetric function for both inflation (Panel a) and output gap (Panel b).

The key difference between the two specifications is that deviations of the same size yield different losses. Indeed, under the symmetric scenario policy makers are assumed to care only about the magnitude of deviations whereas under asymmetric preferences they care also about the sign. In particular, a positive value of α in Panel (a) implies that, everything else equal, deviations of inflation (relative to target) from above are weighted more severely than deviations from below. To see this notice that whenever $\pi_t - \pi^* > 0$ the exponential component of the loss function dominates the linear component while the opposite is true for $\pi_t - \pi^* < 0$. The same reasoning holds for the coefficient γ in Panel (b), which captures any asymmetry in the policy preferences for stabilizing the business cycle. However, if monetary authorities are more concerned about undershooting potential output rather than overshooting it, the value of γ would be negative implying that whenever $y < 0$ the loss rises exponentially whereas it does linearly for $y > 0$.

Furthermore, the linex loss function specified above is so general as to collapse to the symmetric quadratic form for a limiting case of the parameters. Applying twice L'Hôpital's rule on (4), it is possible to show that whenever α and γ tend to zero the central bank objective function reduces to the symmetric parametrization $L_t = \frac{1}{2}\left[(\pi_t - \pi^*)^2 + \lambda y_t^2 + \mu (i_t - i^*)^2\right]$. The latter can be obtained as a quadratic approximation of the utility-based welfare function in a New-Keynesian model of the business cycle that involves a zero lower bound for nominal interest rate (see Woodford, 2003, Ch. 6).

2.3 A nonlinear policy rule

We let monetary authorities choose policy rates in a discretionary fashion. Indeed, the case for an optimal monetary policy without commitment seems to be closer to the actual practice of many Central Banks which rarely tie their hands over the course of future policy actions. Because no endogenous state variable enters the model, the intertemporal policy problem reduces to a sequence of static optimization problems. This amounts to choosing in each period the instrument rate such as to minimize:

$$E_{t-1}\left(\frac{e^{[\alpha(\pi_t-\pi^*)]}-\alpha\left(\pi_t-\pi^*\right)-1}{\alpha^2}\right)+\lambda E_{t-1}\left[\frac{e^{(\gamma y_t)}-\gamma y_t-1}{\gamma^2}\right]+\frac{\mu}{2}\left(i_t-i^*\right)^2+F_t \tag{5}$$

subject to

$$\pi_t = \frac{k y_t}{1-k\tau y_t}+f_t \tag{6}$$

$$y_t = -\varphi i_t+g_t \tag{7}$$

where $F_t \equiv E_{t-1}\sum_{\tau=1}^{\infty}\delta^{\tau}L_{t+\tau}$, $f_t \equiv \theta E_t\pi_{t+1}+\varepsilon_t^s$ and $g_t \equiv E_t y_{t+1}+\varphi E_t\pi_{t+1}+\varepsilon_t^d$ are taken as given reflecting the fact that monetary authorities cannot directly manipulate expectations. The first order condition reads

$$-E_{t-1}\left(\frac{e^{[\alpha(\pi_t-\pi^*)]}-1}{\alpha}\right)\frac{k\varphi}{\left(1-k\tau y_t\right)^2}-E_{t-1}\left(\frac{e^{(\gamma y_t)}-1}{\gamma}\right)\lambda\varphi+\mu\left(i_t-i^*\right)=0 \tag{8}$$

and it implicitly describes a general reaction function according to which the central bank moves policy rates as the optimal, potentially nonlinear, response to the developments in the economy. The important result which underlies equation (8) is that it nests the conventional linear form as a special case. Indeed, it can be shown by means of L'Hôpital's rule that whenever α, γ and τ tend to zero, the reaction function (8) collapses to an implicit interest rate rule of the type proposed by Taylor (1993):

$$-k\varphi E_{t-1}\left(\pi_t-\pi^*\right)-\lambda\varphi E_{t-1}\left(y_t\right)+\mu\left(i_t-i^*\right)=0 \tag{9}$$

This feature is attractive as it delivers a joint restriction on policy makers' preferences and a convex Phillips curve that can be formally tested for. It follows that the hypothesis of a linear reaction function can be challenged by assessing whether the relevant coefficients are, either jointly or marginally, significantly different from zero. The policy parameters α and γ are indeed crucial for the analysis of optimal monetary policy not only because they introduce an asymmetric motive in the central bank objective function but also because, more importantly, they make those asymmetries map into a nonlinear policy rule. This suggests that were α and γ identified, the hypothesis that central bank preferences are symmetric around the target could simply be tested by evaluating the functional form of the policy rule. Hence, evidence of nonlinearity would be informative about which type of asymmetry, if any, is relevant to policy makers.

3 From theory to data

The parameters α, γ, and τ, and the exponential function govern the asymmetric response of policy rates to positive and negative deviations of the state variables from the target. Our task consists in estimating the nonlinear reaction function (8) in order to evaluate whether those parameters are significantly different from zero. This amounts to test linearity against a nonlinear model, which is complicated by the fact that in small samples the estimation criterion is insensitive to the so-called smoothness coefficients as there exists a large set of α- and γ-values yielding almost the same interest rate behavior (see Granger and Teräsvirta, 1993, Ch. 7). Moreover, the reduced-form estimates cannot recover all structural parameters, and in particular α and γ are not identified. A simple transformation of the model that confronts the issue directly involves the linearization of the exponential terms in (8) by means of a first-order Taylor series expansion around $\alpha = \gamma = \tau = 0$:

$$\begin{aligned} &-k\varphi E_{t-1}\left(\pi_t - \pi^*\right) - \lambda\varphi E_{t-1}\left(y_t\right) - \frac{\alpha k \varphi}{2} E_{t-1}\left[\left(\pi_t - \pi^*\right)^2\right] + \\ &-\frac{\lambda\varphi\gamma}{2} E_{t-1}\left(y_t^2\right) - 2k^2\tau\varphi E_{t-1}\left(\left(\pi_t - \pi^*\right) y_t\right) + \mu\left(i_t - i^*\right) + e_t = 0 \end{aligned} \quad (10)$$

with e_t being the remainder of the Taylor series approximation.

This condition relates the policy rates with the expected values of the state variables conditioned upon the information available at time $t-1$. Asymmetric preferences independently introduce a squared component for inflation and output gaps respectively, whereas the nonlinear Phillips curve maps into the cross product of the state variables. We solve equation (10) for i_t and prior to estimation we replace expected inflation and output gaps with actual values. Moreover, as most of the empirical literature, we extend the model to include a partial adjustment mechanism for setting monetary policy rate changes. This yields the following interest rate reaction function:

$$i_t = (1-\rho)\left\{c_0 + c_1(\pi_t - \pi^*) + c_2 y_t + c_3(\pi_t - \pi^*)^2 + c_4(y_t)^2 + c_5\left[(\pi_t - \pi^*)\, y_t\right]\right\} + \rho i_{t-1} + v_t \tag{11}$$

which is linear in the coefficients

$$c_0 \equiv i^*, \quad c_1 \equiv \frac{k\varphi}{\mu}, \quad c_2 \equiv \frac{\lambda\varphi}{\mu}, \quad c_3 \equiv \frac{\alpha k\varphi}{2\mu}, \quad c_4 \equiv \frac{\lambda\varphi\gamma}{2\mu} \quad \text{and} \quad c_5 = \frac{2k^2\tau\varphi}{\mu}$$

and whose error term is defined as

$$\frac{v_t}{(1-\rho)} \equiv -\left\{\begin{array}{c} c_1(\pi_t - E_{t-1}\pi_t) + c_2(y_t - E_{t-1}y_t) + c_3\left[(\pi_t-\pi^*)^2 - E_{t-1}(\pi_t-\pi^*)^2\right] + \\ +c_4\left[y_t^2 - E_{t-1}(y_t)^2\right] + c_5\left[(\pi_t-\pi^*)\,y_t - E_{t-1}\left((\pi_t-\pi^*)\,y_t\right)\right] \end{array}\right\} + \frac{e_t}{\mu}$$

The term in curly brackets is a linear combination of forecast errors and therefore v_t is orthogonal to any variable in the information set available at time $t-1$.

Equation (11) makes clear that by assuming an optimizing central bank behavior the reaction function parameters can only be interpreted as convolutions of the coefficients representing policy makers' preferences and those describing the structure of the economy. Nevertheless, the reduced-form parameters allow now to recover the asymmetric preferences since $\alpha = 2c_3/c_1$ and $\gamma = 2c_4/c_2$. Unfortunately, $\lambda = c_2 k/c_1$ and $\tau = c_5/(2c_1 k)$ cannot be identified unless the parameter k in the Phillips curve is estimated. While such an exercise would also provide a direct evidence on convexity, it is beyond the focus of this paper on asymmetric preferences. Accordingly, rather than using the cross product in (11) to recover τ, we regard it as a control variable for a potentially competing source of nonlinearity in the policy rule. Lastly, since no direct inference can be made on the relative weight on output stabilization, λ, we discuss below a simple way to identify it.

4 The evidence

This section reports the estimates of the ECB reaction function (11) and compares them to estimates obtained for the US Federal Reserve over the same sample and for the German Bundesbank over an earlier sample. The goal is twofold. First, the evidence for the US over such a short period can serve to gauge the plausibility of our small-sample estimates relative to the findings of nonlinearity for the Fed that has been recently documented by Dolado, Maria-Dolores and Ruge-Murcia (2002) and Surico (2002). Second, the evidence on German monetary policy can be used to establish differences and similarities between the Bundesbank and the ECB.

The empirical analysis is conducted on monthly, seasonally adjusted, aggregated Euro data until October 2002. As the number of observations available since January 1999 appear to be too small to prevent incorrect inference, we expand the sample back to July 1997 when the adoption of the Stability and Growth Pact and the ongoing convergence among most EU economies made the behavior of national aggregates rather homogenous. We end up with 64 observations that span a period of approximately five years. With reference to Germany, we consider the period 1992:2-1998:12 which is meant to capture a stable, euro-converging policy regime starting with the formal constitution of the ECB within the Maastricht Treaty.[1]

The data for Germany and the Euro area have been collected from Eurostat with the exception of the interest rate and the DM/dollar exchange rate which are obtained from the Bank for International Settlements data base. Inflation is measured as the annualized rate of change in the (harmonized) consumer price index, the output gap is constructed as the HP detrended component of the (log) industrial production index (excluding construction) over the period 1984:11-2002:10 while the 3-month money market interest rate (linked to EURIBOR

[1] Actually, the Maastricht Treaty entered into force only on November 1, 1993. Nevertheless, the convergence between Euro area economies appears to be dated earlier.

from January 1999 onwards) represents the short-term policy variable.[2] Long-term interest rates are 10-years government bond yields. The US series have been obtained from the web site of the Federal Reserve Bank of St. Louis. The measures of inflation and output gap are constructed using the same procedures described for their Euro area counterparts whereas the policy variable is now the federal funds rate.

Before proceeding, a word of caution is needed to avoid a misleading interpretation of our point estimates. The short time length and the potential lack of sufficient variation in inflation and output may lead to incorrect inference about the slope coefficients in the policy reaction function. Inspection of Figure 1 reveals indeed that the sample period has not been characterized by unusual volatility. However, it appears to contain sufficient variation in output gap with a standard deviation of 1.34, whereas the standard deviation of inflation is 0.68. While this suggests that the estimates on the inflation response are better interpreted as a lower bound, it also implies that the results must be taken with a grain of salt as they can only represent the ECB conduct of monetary policy in a period of relative inflation stability.

4.1 ECB reaction functions

We estimate equation (11) for the Euro area using the Generalized Method of Moments (GMM) with an optimal weighting matrix that accounts for possible heteroskedasticity and serial correlation in the error terms (see Hansen, 1982). In practice, we employ a twelve lag Newey-West estimate of the covariance matrix. Four lags of the long-short interest rate spread, inflation and output gap are included as instruments corresponding to a set of 6 overidentifying restrictions that can be tested for.[3] The choice of a relatively small number of lags for the instruments is

[2] The use of a low frequency filter to obtain estimates of the target level of real activities does not contrast with the model-based definition of flexible-price level of output. As argued by Woodford (2003), the central bank can make society better off by accommodating technology and preference shocks while offsetting disturbances to inflation and wage mark-ups. In this vein, Smets and Wouters (2003) show that if the monetary authorities wish to hedge against shocks of unknown nature, they would regard persistent disturbances as the only shocks affecting the target level of output. When applied to the estimated New-Keynesian model for the Euro area in Smets and Wouters (2002), they find that the counterfactual flexible-price level of output, which is the one responding to all non-monetary shocks in the economy, is indeed extremely volatile, whereas the target level of output, which is the one only affected by supply and demand disturbances, follows a relatively smooth path.

[3] The choice of long-short spread, as opposed to short-term rate only, comes from the significantly better fit and more precise estimates of the model that the former implies. In selecting the instruments, we also take into account the publication lags that are typically associated with the major statistical agencies, so that agents

meant to minimize the potential small sample bias that may arise when too many overidentifying restrictions are imposed. As a quantitative definition of price stability, we assume $\pi^* = 2\%$ prior to estimation. While broadly in line with the second pillar of the ECB monetary policy strategy (see Issing, 2002b), such a choice does not affect qualitatively any of the results as opposed to the lower alternative 1.5% that has been recently discussed in Issing (2002a), and advocated by Galì (2003), and Gerlach and Svensson (2002).[4]

Table 1 reports the estimates of the ECB feedback coefficients for several nonlinear specifications ranging from the baseline (11) to some forward-looking variants. The first column corresponds to the linear case (i.e. imposing $c_3 = c_4 = c_5 = 0$) and it serves as a benchmark to evaluate the impact of any potential nonlinearity. The last column displays a backward-looking version estimated with OLS and it allows an evaluation of any potential small sample bias of GMM estimates.

The coefficients on squared inflation, c_3, are not significant across all specifications whereas those on squared output, c_4, are always significant and have the expected negative sign. The parameter capturing nonlinearity from the structure of the economy, c_5, shows relevance mainly in the baseline case, consistently with the evidence in Dolado, Maria-Dolores and Naveira (2003), and Peersman and Smets (2002). While the coefficient on the inflation level, c_1, is in most cases statistically lower than one, the cross product of the state variables makes the overall policy response to inflation in line with the so-called Taylor principle, but only for sufficiently large output expansions. Consider for instance the baseline case where beside a value of 0.579 for π_t, there is a significant point estimate of 0.323 for the cross product term $(\pi_t y_y)$. Then, values of the output gap larger than 1.3%, which according to Figure 1 have occurred in the recent history of the Euro area, imply an inflation slope greater than one.[5]

forming expectations at time $t-1$ only have information from period $t-2$. The F-test applied to the first-stage regression rejects the hypothesis of weak instruments.

[4] In particular, the point estimates and the standard errors attached to the nonlinear terms, which make the main argument of the paper, appear to be not significantly different from the baseline case. On the other hand, the constant and the response to the inflation level take values stastically lower when $\pi^* = 1.5\%$.

[5] There exists also an indirect channel through which the Taylor principle may hold for a forward looking policy rule. A real interest rate decrease, as implied by a weak nominal response to anticipated inflation, opens up a demand-driven positive wedge between actual and potential output. According to the state-dependent reaction function, this is likely to imply a stabilizing response stemming from the multiplicative term of the

The interest rate smoothing coefficient displays a fairly robust 0.7 whereas the constant, which corresponds to the policy rate target, takes on average a value of 4.1 somewhat larger than in the linear case. Not surprisingly, neglecting the nonlinear output gap component, which enters the specifications with a negative sign, makes the linear estimates à la Clarida, Galì and Gertler (1998) significantly downward biased. Lastly, the backward estimates replicate reasonably well the GMM results but the one on the inflation level. While this confirms how difficult can it be to identify the inflation slope with such a little variation, it also suggests that the corresponding weak response, c_1, is likely to be sample specific and therefore it may well be overturned as soon as more observations become available.

A number of interesting results emerge from Table 1. First, ECB monetary policy can be characterized by a nonlinear policy rule. Second, no asymmetry can be detected with respect to the objective of price stability. In particular, the baseline estimates translate into an asymmetric inflation parameter that is not statistically different from zero (see the first row of Table 2). Nevertheless, the policy response to inflation appears to be stronger in booms than in recessions through a convex structure of the economy. Third, there exists a significant asymmetry with respect to the business cycle in that output contractions require a more vigorous response than output expansions of the same magnitude. To see this, notice that whenever output is below potential both the level and the square call for a policy easing, whereas they recommend opposite interventions otherwise. In particular, the baseline parameter on squared values maps into a value of γ that is negative and statistically different from zero. Fourth, the overall responses to inflation and to output gaps are state-dependent, though they are associated with opposite phases of the business cycle.

4.2 Inheriting the mantle of the Bundesbank

We extend the empirical analysis to see how the Fed and the Bundesbank conduct monetary policy, using the baseline specification in (11). For Germany, four lags of the US federal funds rate and the real DM/dollar rate are added as instruments. For both Central Banks, the

policy rule.

inflation target is imposed at 2%. This is consistent with the "unavoidable price increase" announced by the Bundesbank (see Bofinger, 2000) and with the Fed target rates reported by the US Council of Economic Advisors (see Dolado, Maria-Dolores and Naveira, 2003).

The first column of Table 3 shows that nonlinearity has played an important role also in the Fed reaction function. In particular, the significance of squared output gap and the multiplicative term translate into asymmetric preference parameters which are both statistically different from zero (see the second row of Table 2). These findings mirror those reported by Surico (2002) using quarterly data over some post-Volcker samples. Moreover, they also line up with the argument made by Dolado, Maria-Dolores and Ruge-Murcia (2002) according to which by allowing for a nonlinear response to inflation it is not possible to reject the hypothesis that the parameter on the level is lower than one. Altogether, our small sample estimates seem to perform reasonably well relative to earlier contributions.

Turning the attention to the Bundesbank, the second column reveals little evidence of nonlinearities over the period 1992:2-1998:12, broadly in line with the results on quarterly data by Cukierman and Muscatelli (2002). However, this does not prevent the asymmetric output gap parameter in the last row of Table 2 from being relevant at the 10% significance level. A comparison with the estimates by Clarida, Galì and Gertler (1998) at monthly frequency over an earlier sample confirms that interest rates have a tendency to adjust slowly whereas the inflation slope and the output gap slope we obtain are respectively lower and higher. Interestingly, Clarida and Gertler (1997) show that while a linear specification of the Bundesbank reaction function implies an inflation slope lower than one, a nonlinear, asymmetric specification makes the overall response in line with the Taylor principle. Moreover, they find the response to output gap to be 0.56. This is consistent with the estimates reported in the second column of Table 3, thereby suggesting that nonlinearity may account, at least partially, for the flatter (steeper) response to inflation (output) we obtain.

The results reported so far allow us to assess differences and similarities between the three Central Banks. To this end, we perform a Clarida, Galì and Gertler-type of experiment.

Suppose that the ECB had followed a policy rule like the one estimated for the Bundesbank and the Fed respectively. Then, it would be possible to construct the counterfactual interest rate series that each alternative rule implies. This amounts to calculating at each point in time the target rate under the three Central Banks' reaction functions, given the historical measure of inflation and output gaps for the Euro area. To the extent that the Fed and the Bundesbank policy management can be referred to as successful examples, this exercise represents a yardstick for evaluating the performance of the ECB monetary policy strategy.

Before proceeding, however, we should emphasize that the specification of the central bank reaction function is state-dependent and therefore our results are better interpreted as sample-specific. This limits somehow the interpretation of the counterfactual experiment for the Bundesbank, whose estimates refer to an earlier period, although we believe that a meaningful comparison can still be drawn relative to the very beginning of the ECB mandate.

Figure 3 plots the target series corresponding to the ECB, the Bundesbank and the Fed behavior respectively (the vertical line corresponds to January 1999). The top panel shows that the target rate estimated under the ECB policy rule effectively describes the behavior of the actual interest rate, thereby providing a satisfactory test of the model.[6] Moving to the counterfactual targets is interesting to notice that both series capture the major swings in the observed policy rate. Moreover, the correlation between the counterfactual Bundesbank target rate and the target rate estimated for the ECB is 0.97, while the one between the latter and the counterfactual Fed target rate is 0.94. However, the US implied path displays substantial differences in magnitude (see the right-hand side scale of the bottom panel), thereby corroborating the view that the Fed response to the 2001 recession has been faster and larger.[7] The results of our experiment, which rely on a model based specification of the policy rule, contrast with

[6]The performance would be even better using fitted rates, which also include lagged interest rates.

[7]Interestingly, in the annual report on Monitoring the European Central Bank edited by Begg et al. (2002) in May, it is argued that ECB policy interventions are somewhat similar to the decisions that a Fed-in-Frankfurt would have taken, and that the size of the gap between the actual and the simulated rate simply reflects the different macroeconomic conditions of the US and the Euro area economies. However, in the December update, the authors seem to refine the argument by leaning towards a more-passive monetary policy stance of the ECB relative to the Fed.

those by Faust, Rogers and Wright (2001), who using an ad hoc reaction function estimated for the Bundesbank find that the Euro area interest rates are lower than the counterfactual values. The linear specification and the longer horizon ahead that they consider seem natural candidates to explain the differences.

We complete the comparative analysis by identifying the relative weight on output stabilization for each Central Bank. To this end, Figure 4 shows λ as a function of k using the baseline estimates for the formula $\lambda = c_2 k / c_1$. The parameter k represents the linear component of the Phillips curve slope, that is the slope that would emerge if τ were zero. In the case of a convex aggregate supply curve (i.e. $\tau > 0$) however, the slope is state-dependent and it is determined by the interactions between k and τ. Conditioned upon a similar structure of the economy, the Fed concern toward output stabilization is twice as large as that estimated for the ECB and the Bundesbank, neither being statistically different from the other. Moreover, when assigned a specific value for k borrowed from the empirical literature (see Galì, Gertler and Lopez-Salido, 2001, for the US and the Euro area, and Benigno and Lopez-Salido, 2002, for Germany), the gap somewhat widens and the preference parameters on output prove to be statistically different from zero.[8] In the light of the large policy responses to the output gap level reported in Table 1 and 3, the relative weight estimates suggest that the three Central Banks all regard output gap mostly as a leading indicator for future inflation, and only to a limited extent as a target per sè.

4.3 Adding a monetary aggregate

The prominent role for money advocated by the first pillar of the ECB strategy calls for an important robustness check of our results to the inclusion of a monetary aggregate. To this end, we enrich the structure of the economy with a money demand relationship, which postulates the quantity of money that must be supplied by the central bank to support a given level of the interest rate. This is a version of the specification derived from microfoundations by

[8] If the structure of the economy were indeed nonlinear (i.e. $\tau > 0$), the estimates of the linear component of the slope, k, would be likely biased as they are derived by implicitly imposing $\tau = 0$. While this suggests some caution about interpreting the point estimates, it does not affect the functional relations displayed in Figure 4.

McCallum and Nelson (1999), and reads the demand for money holdings as a positive function of the output gap and as a negative function of its opportunity cost. To make the model consistent with a money growth rate formulation, we follow Söderström (2001) and we specify the money demand equation in first differences:

$$\Delta m_t = \pi_t + \beta \Delta y_t - \theta \Delta i_t + \varepsilon_t^m \tag{12}$$

The velocity disturbance ε_t^m follows a zero mean-reverting process.

We also augment the one-period loss function accordingly:

$$\begin{aligned} L_t' &= \frac{e^{\alpha(\pi-\pi^*)} - \alpha(\pi_t - \pi^*) - 1}{\alpha^2} + \lambda \left[\frac{e^{(\gamma y_t)} - \gamma(y_t) - 1}{\gamma^2} \right] + \frac{\mu}{2}(i_t - i^*)^2 + \\ &+ \lambda^{\Delta m} \left[\frac{e^{\omega(\Delta m_t - \Delta m^*)} - \omega(\Delta m_t - \Delta m^*) - 1}{\omega^2} \right] \end{aligned} \tag{13}$$

and we let monetary authority to minimize (13) subject to (1), (2) and the additional constraint (12). This leads to a linearized version of the optimal policy rule that is all alike the one in (11) but three new components, namely $(\Delta m_t - \Delta m^*)$, $(\Delta m_t - \Delta m^*)^2$ and $(\Delta m_t - \Delta m^*) y_t$, whose coefficients are given respectively by

$$c_6 = \frac{\lambda^{\Delta m}[\varphi(k+\beta)+\theta]}{\mu}, \quad c_7 = \frac{\omega\lambda^{\Delta m}[\varphi(k+\beta)+\theta]}{2\mu} \quad \text{and} \quad c_8 = \frac{2\lambda^{\Delta m}k^2\tau\varphi}{\mu}$$

The analytical approach to the solution of the optimal control problem allows to identify both the relative weight on money growth stabilization, $\lambda^{\Delta m} = c_8/c_5$ and the asymmetric preference parameter, $\omega = 2c_7/c_6$.

The right bottom panel of Figure 1 displays the (log) M3 annual growth rate. The series appears not only to contain sufficient variation to identify its slope in the policy rule (the standard deviation is 1.16), but it also shows a persistent pattern above the reference value of 4.5%, with the period 2000:7-2001:3 being the most notable exception. We estimate the money augmented policy rule with GMM expanding the instruments used in the baseline case to include five lags of the M3 growth rate. Prior to estimation, we subtract the reference value from Δm_t. The results are reported in Table 4.

The linear estimates present an unexpected negative coefficient on money growth, which is however overturned in the nonlinear specification. In particular, while the level does have explanatory power only at 10% significant level, the square of the M3 growth rate, which features an asymmetric behavior, takes a negative and highly significant value. However, the corresponding preference parameter, $\lambda^{\Delta m}$, is not statistically different from zero. Interestingly, the latter does not imply that monetary aggregates are unimportant in ECB policy actions. On the contrary, the M3 money growth rate appears to be monitored as a leading indicator for future values of the state variables rather than as a target per sè in that it enters the reaction function but not the policy objectives.[9] Moreover, taking into account the few number of observations below 4.5%, the positive value of c_6 combined with the negative value of c_7 implies an asymmetric response that requires little adjustment, if any, above the reference value but calls for more vigorous interventions below it. Lastly, the reduced-form and the preference parameters on inflation and output gaps as well as the asymmetric characteristics of the policy rule appear to be robust to the inclusion of a monetary aggregate. This is consistent with the estimates in Gerdesmeier and Roffia (2003), who show using harmonized Euro area data over the sample 1985:01-2002:2 that even though the money growth gap may significantly enter the interest rate reaction function, the point estimates for inflation and the output gap would be unaffected.

5 Conclusions

Inflation targeting has become by now the common language spoken by policy makers, researchers and economic advisors. As pointed out by a vast literature on the topic, such an operational framework is better understood in the form of the announcement of an explicit loss function with numerical relative weights on output gap stabilization (see Svensson, 2003). To the extent that the ECB monetary policy strategy can be described as inflation targeting, this paper offers a preliminary evaluation of the first years of the Eurosystem through the es-

[9] See Gerlach and Svensson (2002), Issing et al. (2001), Nicoletti-Altimari (2001), and Trecroci and Vega (2002) for a detailed empirical evidence on the information content of M3 money growth rate.

timates of the policy preferences of the European Central Bank. In so doing, it generalizes the conventional quadratic form of the loss function by allowing policy makers to weight differently positive and negative deviations of inflation and output from the target values.

The empirical analysis using aggregated Euro area data over the sample 1997:7-2002:10 shows that the ECB monetary policy can be characterized by a nonlinear, state-dependent policy rule featuring a number of results. First, while equal concern appears to be given to the risks of inflation as well as deflation, the policy preference on output stabilization is found to be asymmetric in that negative deviations of a given amount imply larger policy easing than the tightening required by positive deviations of the same size. Second, consistently with the primary objective of price stability, the ECB weight on output stabilization is from one tenth to one fourth as large as the weight on inflation stabilization. Moreover, such a relative preference is not statistically different from the one estimated for the Bundesbank over an earlier sample, whereas it is halved with respect to the preference estimated for the Fed over the same period. Third, when compared to the counterfactual interest rates constructed using historical Euro area data and the reaction function estimates for Germany and the US, the observed path of the interest rate highly commoves with those that the Bundesbank and the Fed would have followed if placed in Frankfurt. However, the actual Euro policy rate is much less volatile than the one implied by a Fed-type of behavior. Fourth, the specification of a monetary aggregate relation in both the policy makers' objectives and the structure of the economy reveals that M3 growth rate is only a leading indicator for future inflation rather than also a target variable per sè, consistently with the communication policy adopted by the ECB (see Issing, 2002b).

While the unavoidable short time length suggests some caution about interpreting these results, we discuss the extent to which our estimates shed lights on Euro area monetary policy. Further empirical investigation however is clearly needed and as soon as more data become available our identification method for (asymmetric) policy preferences might prove to be a simple framework to evaluate the performance of the ECB.

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Table 1: Reduced-Form Estimates of the ECB Reaction Function
- sample: 1997:07 2002:10 -

		Nonlinear			
			Forward (k)		*Backward*
	Linear (CGG)	*Baseline*	*(1)*	*(3)*	*OLS*
c0	3.769**	4.176**	4.236**	4.379**	3.986**
	(0.056)	(0.152)	(0.169)	(0.303)	(0.113)
c1	0.771**	0.579**	0.545**	0.845**	0.320**
	(0.106)	(0.185)	(0.112)	(0.390)	(0.102)
c2	0.470**	0.602**	0.577**	0.608**	0.532**
	(0.069)	(0.050)	(0.052)	(0.074)	(0.058)
c3	0	0.163	0.092	0.310	-0.041
	-	(0.178)	(0.162)	(0.552)	(0.172)
c4	0	-0.270**	-0.249**	-0.366**	-0.110**
	-	(0.068)	(0.083)	(0.188)	(0.043)
c5	0	0.323**	0.280*	0.415	0.098
	-	(0.128)	(0.144)	(0.292)	(0.093)
ρ	0.767**	0.701**	0.700**	0.765**	0.717**
	(0.027)	(0.038)	(0.051)	(0.074)	(0.045)
J(6)		2.031	2.948	3.454	-
J(9)	3.364				

Specification:

$$i_t = (1-\rho)(c_0 + c_1\pi_t + c_2 y_t + c_3\pi_t^2 + c_4 y_t^2 + c_5(\pi_t y_t)) + \rho i_{t-1} + v_t$$

Standard errors using a twelve lag Newey-West covariance matrix are reported in brackets. The dependent variable is the 3-month money market interest rate, inflation is measured as annualized changes in the harmonized index of consumer-price and output gap is obtained from detrending the log of the industrial production index with an HP filter (smoothing parameter=14400). Four lags of hicp inflation, output gap, and long-short interest rate spread are included as instruments. k represents the number of months ahead for inflation. J(*m*) refers to the statistics of Hansen's test for *m* overidentifying restrictions which is distributed as a $\chi^2(m)$ under the null hypothesis of valid overidentifying restrictions. The superscript ** and * denote the rejection of the null hypothesis that the true coefficient is zero at the 5 percent and 10 percent significance levels, respectively.

Table 2: The Asymmetric Policy Preferences

Baseline case	*Inflation (α)*	*Output gap (γ)*
European Central Bank 1997:07 – 2002:10	0.562 (0.546)	-0.899** (0.180)
US Federal Reserve 1997:07 – 2002:10	1.119* (0.572)	-0.457** (0.046)
Bundesbank 1992:02 – 1998:12	0.105 (0.354)	-0.572* (0.329)

Standard errors in parenthesis. The calculations of the point estimates as well as the standard errors of the ECB asymmetric preferences are based on the estimates of the baseline specification. The superscript ** and * denote the rejection of the null hypothesis that the true coefficient is zero at the 5 percent and 10 percent significance levels, respectively.

Table 3: Reduced-Form Estimates of other CBs Reaction Function

	Federal Reserve	*Bundesbank*
Sample	*1997:7 – 2002:10*	*1992:2 1998:12*
c0	3.835** (0.140)	4.141** (0.322)
c1	1.033** (0.348)	0.839** (0.316)
c2	2.403** (0.174)	0.856** (0.256)
c3	0.579 (0.445)	0.044 (0.137)
c4	-0.549** (0.083)	-0.244* (0.133)
c5	0.722** (0.119))	0.216* (0.126)
ρ	0.617** (0.121)	0.917** (0.025)
J(6)	1.594	
J(14)		6.241

Specification:

$$i_t = (1-\rho)(c_0 + c_1\pi_t + c_2 y_t + c_3\pi_t^2 + c_4 y_t^2 + c_5(\pi_t y_t)) + \rho i_{t-1} + v_t$$

Standard errors using a twelve lag Newey-West covariance matrix are reported in brackets. For the US, the dependent variable is federal funds rate, inflation is measured as annualized changes in the GDP chain-type price index and output gap is obtained from the Congressional Budget Office converting quarterly data to monthly data with a cubic-match last interpolation. Four lags of gdp inflation, cbo output gap, and long-short interest rate spread are included as instruments. For Germany, the dependent variable is the 3-month money market interest rate, inflation is measured as annualized changes in the consumer price index and output gap is obtained detrending the log of the industrial production index with an HP filter (smoothing parameter=14400). Four lags of cpi inflation, output gap, long-short interest rate spread, the real DM/$ exchange rate and the federal funds rate are included as instruments. J(*m*) refers to the statistics of Hansen's test for *m* overidentifying restrictions which is distributed as a $\chi^2(m)$ under the null hypothesis of valid overidentifying restrictions. The superscript ** and * denote the rejection of the null hypothesis that the true coefficient is zero at the 5 percent and 10 percent significance levels, respectively.

Table 4: Reduced-Form Estimates of the ECB Reaction Function
- adding M3 money growth rate -

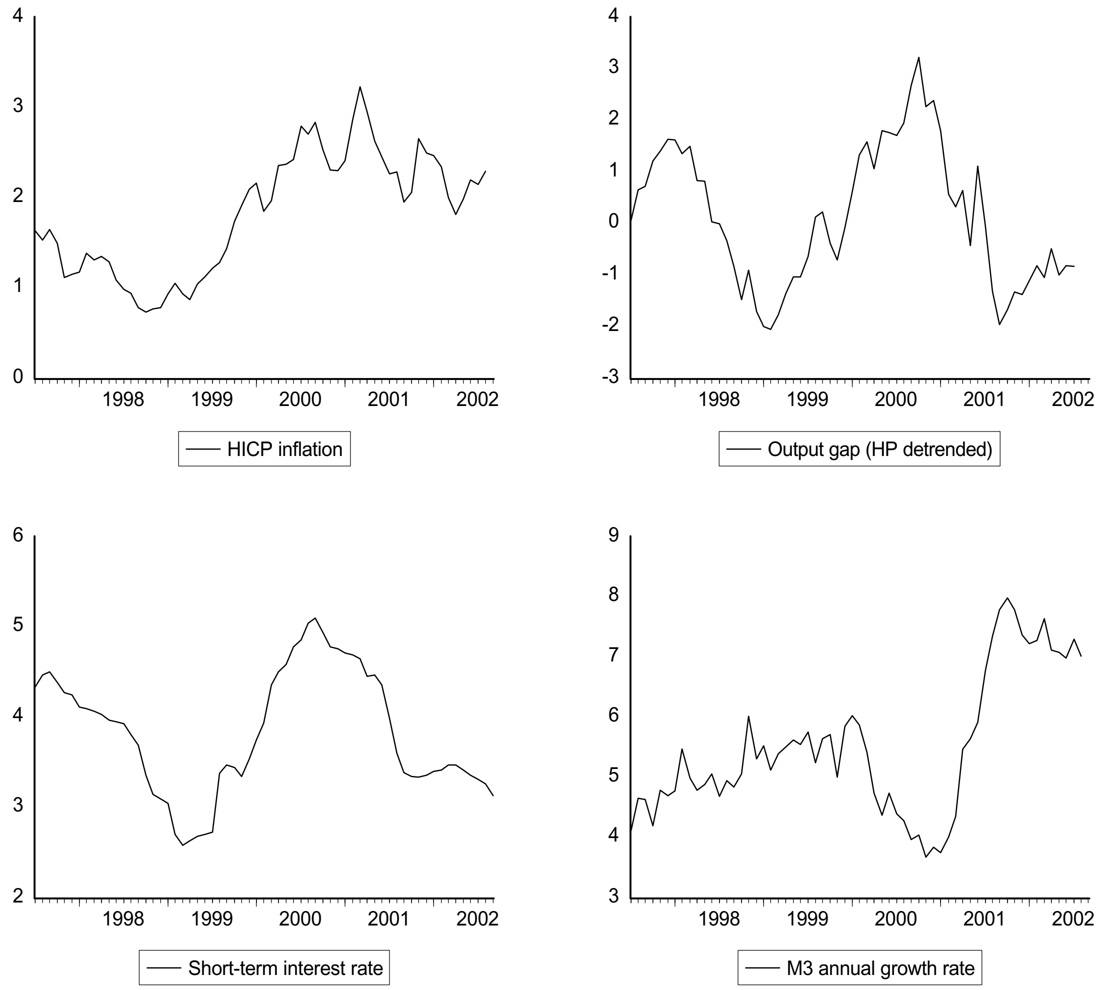
	Linear	*Nonlinear*
c0	4.175**	4.428**
	(0.075)	(0.387)
c1	0.540**	0.585**
	(0.076)	(0.175)
c2	0.452**	0.455**
	(0.053)	(0.155)
c3	0	-0.480
	-	(0.344)
c4	0	-0.154**
	-	(0.056)
c5	0	0.267**
	-	(0.114)
c6	-0.186**	0.418*
	(0.051)	(0.230)
c7	0	-0.225**
	-	(0.084)
c8	0	0.026
	-	(0.133)
$\boldsymbol{\rho}$	0.652**	0.762**
	(0.028)	(0.041)
$\boldsymbol{\lambda^{\Delta m}}$	0	0.099
	-	(0.482)
J(9)		2.168
J(13)	3.942	

Specification:

$$i_t = (1-\rho)(c_0 + c_1\pi_t + c_2 y_t + c_3\pi_t^2 + c_4 y_t^2 + c_5(\pi_t y_t) + c_6\Delta m_t + c_7\Delta m_t^2 + c_8(\Delta m_t y_t)) + \rho i_{t-1} + v_t$$

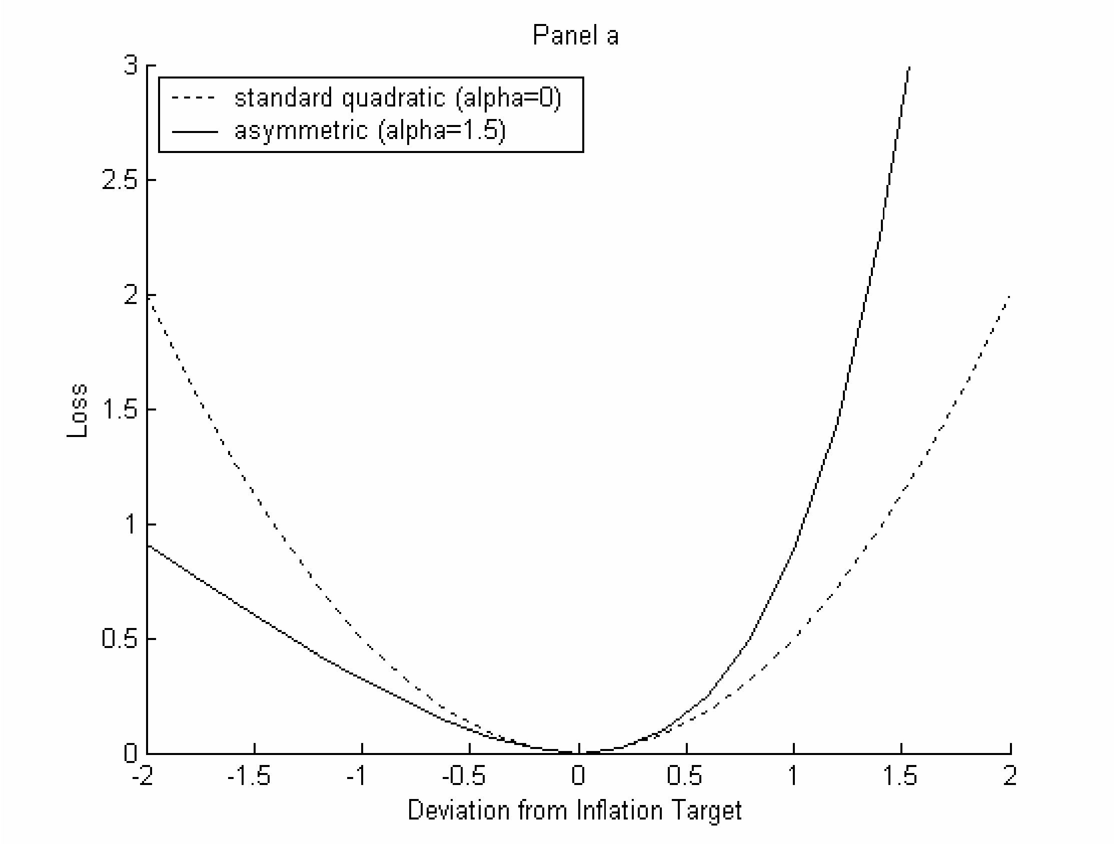
Standard errors using a twelve lag Newey-West covariance matrix are reported in brackets. The dependent variable is the 3-month money market interest rate, inflation is measured as annualized changes in the harmonized index of consumer-price and output gap is obtained from detrending the log of the industrial production index with an HP filter (smoothing parameter=14400). Four lags of hicp inflation, output gap, long-short interest rate spread and five lags of M3 money annual growth rate are included as instruments. J(*m*) refers to the statistics of Hansen's test for *m* overidentifying restrictions which is distributed as a $\chi^2(m)$ under the null hypothesis of valid overidentifying restrictions. The superscript ** and * denote the rejection of the null hypothesis that the true coefficient is zero at the 5 percent and 10 percent significance levels, respectively.

Figure 1 – Some Macro Aggregates for the Euro Area



Sample 1997:7-2002:10. Inflation is measured as annualized changes in the harmonized index of consumer-price. Output gap is obtained from detrending the log of the industrial production index with an HP filter over the period 1984:11-2002:10. Short-term interest rate is the 3-month money market interest rate (linked to Euribor from 1999:1 onwards). M3 growth rate is calculated as annual changes of the log of the monetary aggregate M3.

Figure 2 – Quadratic vs. Asymmetric Preferences



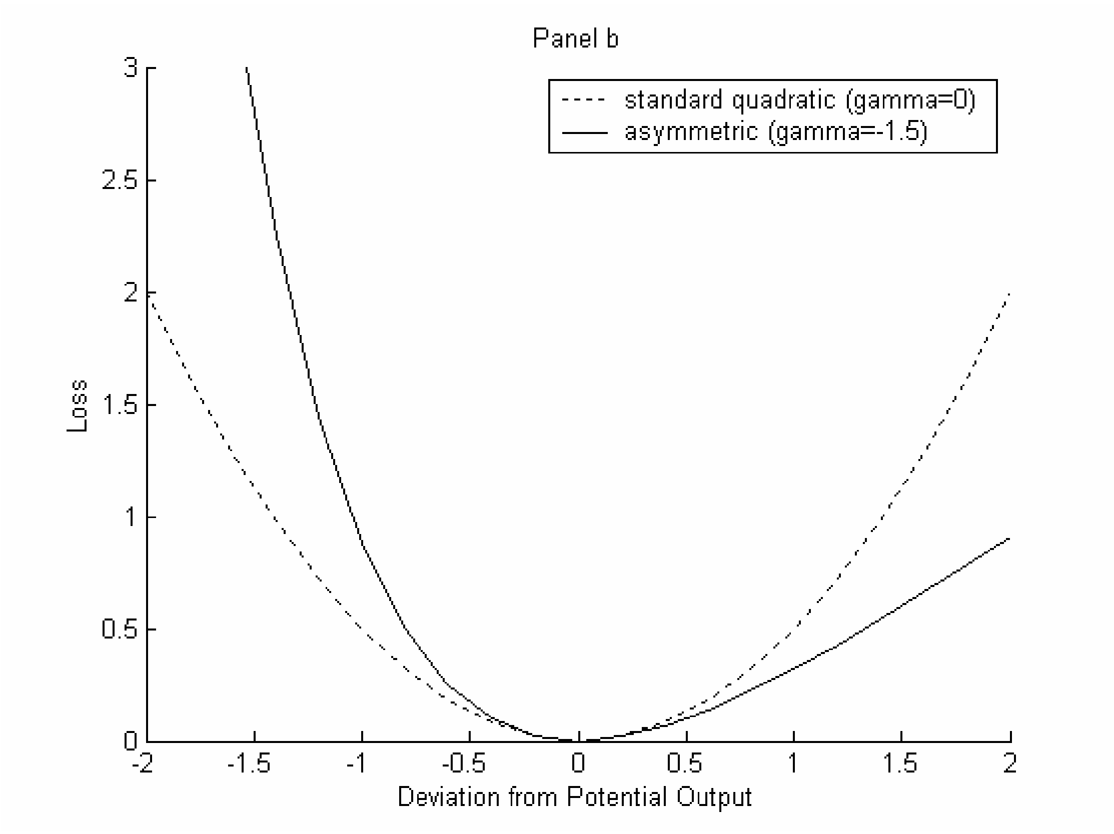
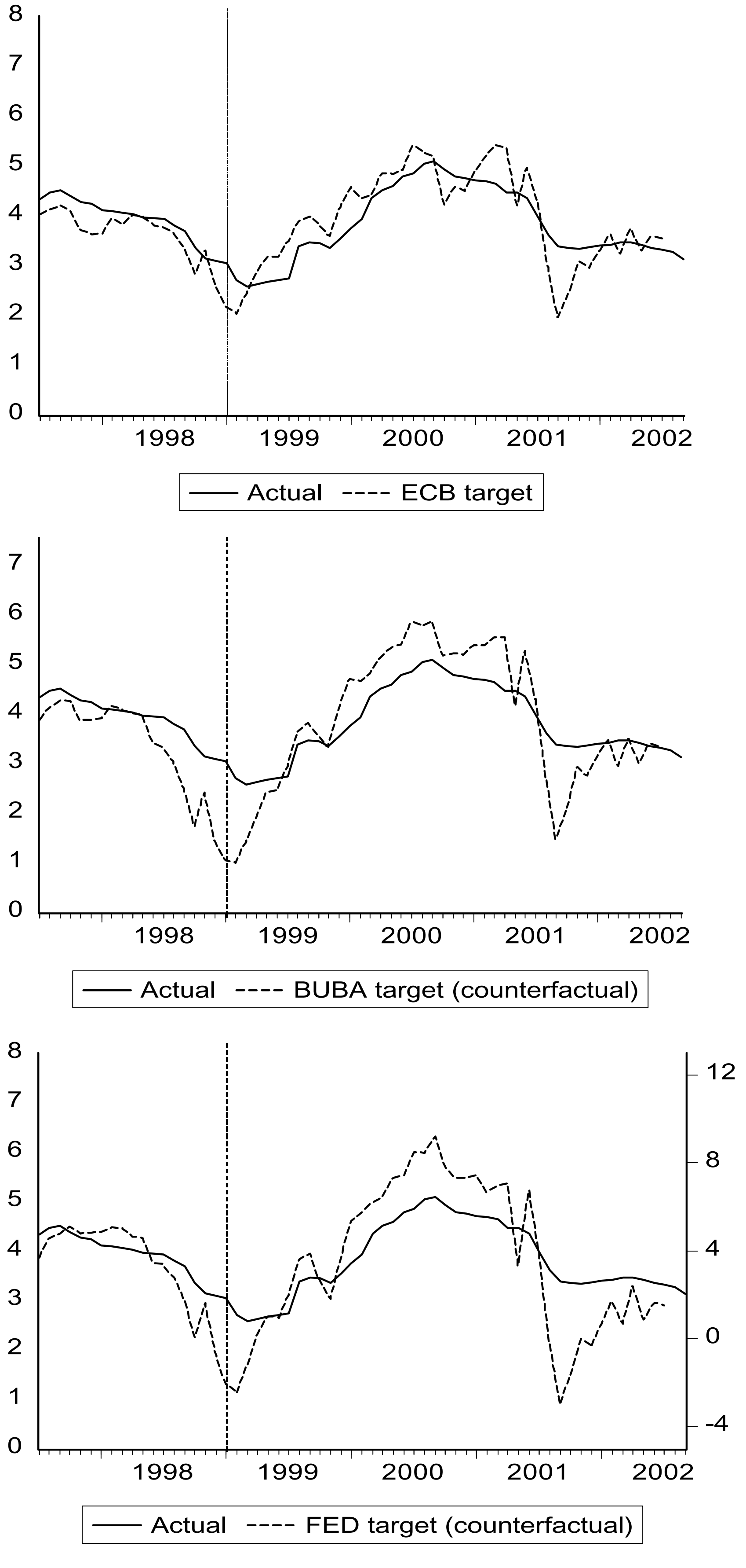
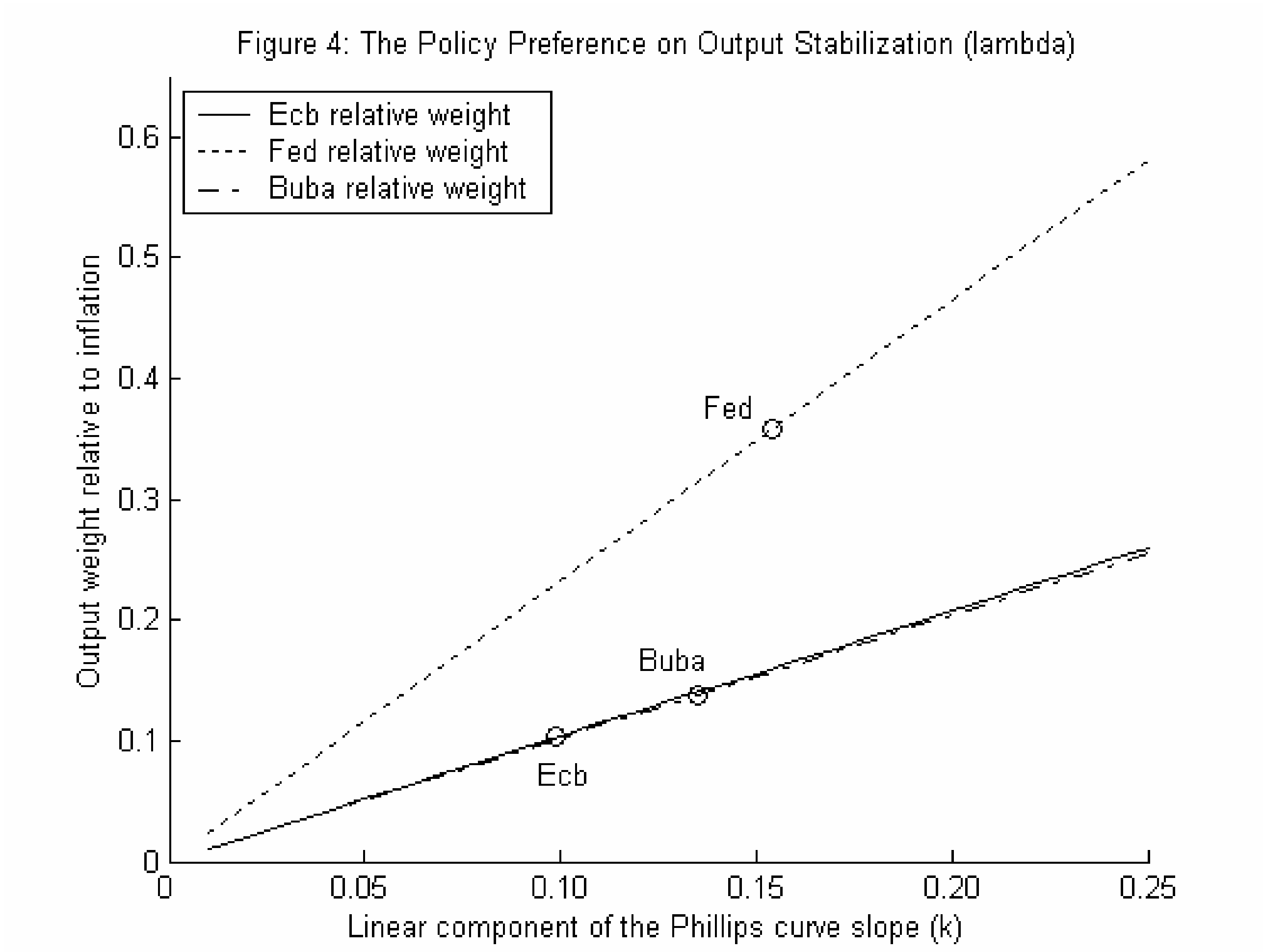


Figure 3 - Euro interest rate: targets vs. actual





The point estimates conditional to the value of the linear component of the Phillips curve slope are:

	Ecb	*Buba*	*Fed*
Relative weight λ	0.103	0.137	0.358
(s.e.)	(0.022)	(0.078)	(0.115)
Linear slope k	0.099	0.135	0.154
(source)	Gali` et al (2001)	Benigno et al. (2002)	Gali` et al (2001)

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