Testing for Asymmetries in the Preferences of the Euro-Area Monetary Policy-maker

Alvaro Aguiar and Manuel M. F. Martins

CEMPRE*, Faculdade de Economia, Universidade do Porto

May 2005

Preliminary Version

Abstract

This paper extends previous work on the preferences of the Euro-Area monetary policy-maker, testing for asymmetries in the loss-function coefficients with post-1995:I aggregate quarterly data from the last update of the ECB's Area-wide database. Following recent literature, we conduct a joint GMM estimation of the Euler equation of optimal policy with the aggregate-demand - aggregate supply structure of the economy. This paper's extension consists of allowing and testing for different loss-function coefficients across diverse states of the economy, in which case the central bank would attach different weights to one of its objectives – inflation targeting, output gap stabilization, or interest rate smoothing – in positive and negative deviations from the policy target. This approach improves the understanding of the evidence on the Euro-Area monetary policy-making during 1995-2004, specifically supporting the hypothesis that the Area's policy-maker has had a precautionary demand for price stability, which is consistent with the acquirement of credibility expected at the onset of a new monetary regime.

Keywords: Central Bank Preferences, Asymmetry, Euro Area, Optimal Control, GMM.

JEL classification: E52, E58, C32, C61.

* **CEMPRE** - Centro de Estudos Macroeconómicos e Previsão - is supported by the Fundação para a Ciência e a Tecnologia, Portugal, through the Programa Operacional Ciência, Tecnologia e Inovação (POCTI) of the Quadro Comunitário de Apoio III, which is financed by FEDER and Portuguese funds.

Please address correspondence to Manuel M.F. Martins (mmfmartins@fep.up.pt), Faculdade de Economia, Universidade do Porto, Rua Roberto Frias 4200-464 Porto, PORTUGAL; +351225571100, ext. 284 (phone); +351225505050 (fax).

Testing for Asymmetries in the Preferences of the Euro-Area Monetary Policy-maker

1. Introduction [1]

The purpose of this paper is to formally examine whether there is significant evidence of asymmetries in the revealed preferences of the Euro Area monetary policy-maker.

Most of the empirical analysis of monetary policy preferences to date has assumed that the preferences of the policy-maker may be modeled by symmetric quadratic loss functions. Within such a context, Aguiar and Martins (2005a) have found that the aggregate Euro Area data uncovers the existence of a well-defined monetary policy regime of strict inflation targeting with interest rate smoothing in 1995:I-2002:IV, following an approach similar to Favero and Rovellis' (2003) study of the US case.

However, the hypothesis that the shape of policy-makers' loss functions may not be identical during different states of the macro-economy is receiving a growing interest in the literature. On one hand, Cukierman (2000, 2002) has suggested that credible central banks may have a precautionary demand for expansions, *i.e.* would rather have a positive than a negative output gap given a particular inflation level. On the other hand, Goodhart (1998) has claimed that central banks with a need to build credibility may have a precautionary demand for price stability, *i.e.* would rather have inflation below than above the target, everything else equal.

Whereas discriminating between symmetric and asymmetric loss functions would clearly improve the knowledge about the preferences of monetary policy-makers, examples of formal loss function asymmetry tests do not abound in the literature. Some works have tested for asymmetries in policy reaction functions, which may be uninformative about the loss function if any asymmetry exists in the structure of the macro-economy, while others have tested loss function asymmetry in the context of purely static or forward-looking macro structures, which are not data-consistent.

In this paper we improve the framework of Aguiar and Martins (2005a) by relaxing the assumption of a quadratic policy-maker loss function, allowing and testing for different loss coefficients across some alternative cyclical states of the economy and policy, in a framework that nests the standard symmetric framework. The baseline

[1] We thank Fabio Canova's comments and suggestions to an earlier version of this paper. The usual disclaimer applies.

model consists of a Rudebusch – Svensson - style (data-consistent) aggregate demand-aggregate supply (AD-AS) macroeconomic structure and the Euler equation solving for optimal discretionary policy, and the econometric strategy entails a GMM joint estimation of the three equations with the relevant cross-equation restrictions. Allowing for asymmetries in the policy-maker's preferences results in an Euler equation that may be non-linear in at least one of the loss function target-variables. The resulting non-linear system may be estimated by GMM, for a given inflation target, yielding estimates of all the model coefficients, including the varying parameters of the loss function, and formal tests for the null hypothesis of linearity of this function are straightforward.

The empirical analysis focuses on quarterly aggregate Euro Area data for 1995:I-2004:III, mostly from the last update of the ECB's Area Wide Model Database (AWM12up5) available since August 2004[2]. As regards the output gap, following Aguiar and Martins (2005a) we use a *quasi-real-time* output gap, in contrast with the *ex-post* measures that are often used in monetary policy analysis, as an attempt to approach the *real-time* data available to policy-makers at the time policy had to be decided.

The main result is that there is evidence, 5-percent significant, that the Euro Area monetary policy-maker has had a precautionary demand for price stability, during 1995-2004. This seems consistent with the fact that during the main part of this period the crucial task for the Euro Area monetary policy-maker – either the notional policy-maker ahead of the EMU, in 1995-1998, as the newly created ECB, in 1999-2004 - has been to establish its (anti-inflationary) credibility.

The rest of the paper is outlined as follows. In section 2 we briefly review the literature and recent empirical results on asymmetries of monetary policy preferences. Then, in section 3 we present our model and econometric strategy. Section 4 presents the data and the empirical results, and offers some discussions. Finally, section 5 lays out some concluding remarks.

2. The case for Asymmetric Monetary Policy-maker's Preferences

In this section we review the recent literature and main empirical results on asymmetric loss functions, and present the specific motivations for testing this asymmetry regarding the Euro Area policy-maker, as well as the main features of this paper's contribution.

[2] We thank Elvira Rosati, of the ECB, for providing this latest version of the AWMD.

Conventionally, policy-makers' preferences have been modeled with symmetric quadratic loss functions, in which the same weights are attached to equally sized positive and negative deviations of the goal variables from their targets. Motivations for this assumption include plausibility, analytical tractability, and clearness of the results. Yet, the hypothesis that the true preferences of monetary policy-makers may be asymmetric has received a lot of interest in recent literature, in two strands of literature.

On a first strand, Cukierman (2000, 2002) has argued that even though central bankers dislike deviations of inflation from the target as well as negative output gaps, for a given level of inflation they do not have interest in offsetting positive output gaps. The claim is that the political establishment is sensitive to the social costs of recessions, and that in democratic societies even independent - but accountable - central banks are not totally insensitive to social pressures and to the desires of the political establishment. This hypothesis has practical appeal in as much as it seems consistent with many insiders' descriptions of policy, such as the much cited Blinder's (1998, p. 19-20): "In most situations the CB will take far more political heat when it tightens preemptively to avoid higher inflation than when it easies preemptively to avoid higher unemployment". Moreover, it has the theoretical appeal of offering an explanation for the inflationary bias in the monetary policy of the 1960s and 1970s that does not hinge on the Kydland-Prescott/Barro-Gordon (KP/BG) assumption that policy-makers target output above its natural level. In fact, a policy-maker with a loss function featuring Cukierman's asymmetry would tackle the uncertainty of policy-making choosing rather to err on the side of ease than on the side of tightness, *i.e.*, would have a precautionary demand for expansions – see Gerlach (2003) for a formal analysis, and Cukierman and Gerlach (2003), and Ruge-Murcia (2003a) for reduced-form tests of this hypothesis.

On a second strand of the literature, Goodhart (1998) has pointed out that a policy-maker trying to create its credibility as an inflation fighter would react to uncertainty preferring negative rather than positive deviations from the inflation target. In this case, the policy-maker would have a precautionary demand for price stability, from which a deflationary bias would arise - a class of bias that had been mentioned before in the context of the creation of a new commitment to low inflation by developed countries during the 1980s - see Fischer (1994). In such contexts of credibility build-up, the hypothesis of precautionary demand for price stability seems plausible and could improve on the quadratic functions as a description of the preferences of policymakers - see Ruge-Murcia (2003b) for a time-series test of this hypothesis. As inflation is typically a pro-cyclical variable, Goodhart (1998) notes, this precautionary demand for price stability may counteract Cukierman's precautionary demand for expansions, and possibly even neutralize it.

Given these two conflicting hypothesis about the shape of the possible asymmetry in central banks' preferences, many researchers undertook the approach of testing for asymmetry encompassing both precautionary demands – for expansions and for price stability. The majority of this research has focused on the estimation of non-linear policy reaction functions (for a variety of samples and with a variety of non-linear specifications) exploiting the well-known result that if an asymmetry in central bank preferences exists, then the optimal policy rule is non-linear – see Bec *et al.* (2002), Kim *et al.* (2002), Cukierman and Muscatelli (2002), Martin and Milas (2004), Karagedikli and Lees (2004), and Bruinshoofd and Candelon (2005).

However, evidence of non-linearity in policy reaction functions may be ultimately uninformative about the shape of the policy-maker loss function: as policy reaction coefficients are complex convolutions of the deep parameters of the economy, its non-linearity could derive from a non-linearity in the structure of the macro-economy and not in the policymaker's preferences. Dealing with this issue claims for specifying and solving a structural model of the economy so as to back-out the coefficients and shape of the policy-maker's loss function.

Examples of this line of research are much more scarce, however, and seem limited to Dolado *et al.* (2004) and Surico (2003, 2004). Dolado *et al.* (2004) have shown that an asymmetric loss function of the *linex* functional form and a macro-economic structure of the Rudebusch-Svensson type generate an optimal policy reaction function that includes the conditional variance of inflation, beyond the standard Taylor rule regressors. With this set-up, they found evidence of a precautionary demand for price stability in the US after 1983 but not before 1979. Surico (2003, 2004) shows that the analytical solution of the policy-maker optimization problem for a loss function with *linex* forms in both inflation and the gap, under a forward-looking AD-AS structure, results in an interest rate rule that includes the square of the output gap and of inflation deviations from target, and devised tests on its coefficients that allow for inference on the loss function non-linearity. While Surico (2003) finds that monthly Euro Area data for 1997:7-2002:10 reveals a precautionary demand for expansions, Surico (2004) finds a precautionary demand for expansions in the US monetary policy before 1979 and no sign of any asymmetry thereafter.

Both these studies seem to have some drawbacks, however. Dolado *et al.* (2004) have to restrict their policy-maker loss function to a regime of strict inflation targeting and thus are not able to test for Cukierman's asymmetry. Moreover, their econometric strategy is not a truly simultaneous estimation of the macro system, as the conditional variance of inflation included in the optimal policy reaction function is generated in a first step prior to the rule estimation. In turn, Surico (2003, 2004) models the AS-AD structure of the economy with purely forward-looking equations, with the lack of any source of persistence implying that his model is not data-consistent, and hence could lead to untrustworthy results. Due to these problems, it is hard to assert whether Dolado *et al.*'s and Surico's empirical results on the US case are incompatible or complementary.

While the literature of formal analysis of central bank preferences asymmetry, just briefly reviewed, exposes the need for methodological contributions, it also reveals that the Euro Area case has barely been studied to date – the only exception being Surico (2003). Yet, there are at least two compelling motivations for a study of the possible asymmetry in the preferences of the aggregate Euro Area monetary policy-maker.

First, many observers see an indication of asymmetric preferences in the ECB's definition of price stability - "a year on year increase in the Harmonised Index of Consumer Prices for the Euro Area below 2 percent." (ECB, 2004, p.50), further clarified in May 2003 with the statement that the ECB "aims to maintain inflation rates below but close to 2 percent over the medium term." (ECB, 2004, p. 51). Asymmetric preferences over inflation would exist in the sense that 2 percent annual inflation is the ceiling consistent with price stability, with negative deviations from that limit preferred to positive deviations – at least when dealing with small deviations.

Second, the fact that the ECB has been created very recently not only calls for a study of its behavior and its (very much unknown) implicit preferences, as also may offer good substance for a case-study. In fact, the study of a new policy-maker of a new monetary area is a privileged opportunity to assess the plausibility of Goodhart's hypothesis that central banks engaged in the establishment of its credibility are prone to have a precautionary demand for price stability. From this point of view, Surico's (2003) evidence of a precautionary demand for expansions by the Euro Area policy-maker between 1997 and 2002 is evidently surprising.

Given the above reviewed state of the literature, this paper tries to contribute both at a methodological and at an applied level.

As regards method, we suggest a framework that allows for testing all economically relevant asymmetries in the central bank loss function, given a data-consistent macroeconomic structure. Specifically, we develop Aguiar and Martins' (2005a) GMM simultaneous estimation of a Rudebusch-Svensson-style AS-AD macroeconomic structure with the policy-maker's Euler equation. The development consists of allowing the policy-maker's loss function to be threshold-quadratic, with different coefficients associated to positive and negative deviations of the policy variables from their targets, leading to non-linearities in the Euler equation. The econometric strategy allows for the retrieval of the loss function coefficients and the remaining (AS-AD) structural coefficients of the model, thus avoiding confusion about the source and nature of any revealed asymmetry in policy preferences, and assuring that the uncovering of such asymmetries is independent from the shape of the macro structure (assumed to be linear throughout this paper). Further to discriminating between precautionary demands for expansions and for price stability, the method may also detect asymmetry in interest rate smoothing. This third kind of asymmetry in preferences, virtually unexamined to date, seems to be implicit in Goodhart's (1997) contention that because interest rate increases are normally seen as bad news while decreases are perceived as good news, central bankers may possibly tend to increase rates less regularly and in larger jumps and to decrease them in a smoother way.

At an applied level, the paper offers evidence on the case of the aggregate Euro Area policy-maker, extending the results of Aguiar and Martins (2005a). On the basis of their dating – drawn from a combination of facts, literature, and econometric results – the sample period begins in 1995:I, with the pre-EMU data having the crucial role of allowing for estimation with quarterly data, thus avoiding the shortcomings of monthly data – excess of volatility and inability to parsimoniously account for the cyclical condition of the whole economy. As regards data, the paper makes a first step in bringing together the literature on asymmetric policy preferences and that on the use of real-time information in policy analysis. While using truly real-time output gaps is unfeasible, for the sample period under study, our *quasi-real-time* output gap is meant to be closer to the information available to policy-makers at the time decisions had to be made, than the *ex-post* gaps that have been used routinely in this literature.

3. A framework for testing for asymmetries in the preferences of the policy-maker: the case of the Euro Area

In this section we present the model, its variables, and the econometric strategy for testing for asymmetries in the policy-maker's preferences.

The structure of the macro-economy is modeled with the following version of the Rudebusch-Svensson dynamic backward-looking model fitted to Euro Area data by Aguiar and Martins (2005a):

$$\begin{cases} y_t = c_1 + c_2 y_{t-1} + c_3 y_{t-2} + c_4 y_{t-3} + c_5 (i_{t-3} - \pi_{t-3}) + \varepsilon_t^{AD} \\ \pi_t = c_6 \pi_{t-1} + c_7 \pi_{t-2} + c_8 \pi_{t-3} + (1 - c_6 - c_7 - c_8)\pi_{t-4} + c_9 x_t + c_{10} SS_{t-1} + \varepsilon_t^{AS} \end{cases} \quad (1)$$

The first equation, the aggregate demand (AD), links the output gap, y, to its past, and to the real interest rate, i-π. The second equation, the aggregate supply (AS), relates inflation, π, to its past, to the output gap, and to exogenous supply shocks, SS. Dynamic homogeneity is imposed into the AS, as the data does not reject that hypothesis in unconstrained estimation, and has the advantages of reducing the number of coefficients to estimate and have the model complying more clearly with the natural rate hypothesis. This model implies a dynamic behavior of the economy and a transmission of monetary actions that is consistent with the evidence in several studies of the aggregate Euro Area; and it is close to the view that actual policy-makers have of the macro-economy, as it realistically features persistence in the macroeconomic variables and lags in the impact of policy - where the purely forward-looking or static models sometimes used in recent research feature *jump-variables* and policy with instantaneous effects.[3]

All data are quarterly time-series for 1995:I-2004:III for the aggregate Euro Area. The source is the ECB, except for the output gap, which has been computed by the authors as described below. For 1995:I-2003:IV, the numbers are those of the latest update of the ECB's Area Wide Model Database (AWM12up5, available since September 2004), while for 2004:I-2004:III consistent updates have been obtained from the ECB's monthly bulletin of December 2004.

The inflation rate - π - is 400 times the first difference of the log of quarterly GDP deflator (*YED* in the AWM12up5). The nominal short-term interest rate - i - is the quarterly average of the 3-month interest rate Euribor (*STN*), in percentage points. The

[3] As the centre of this paper is testing for asymmetric policy preferences, we maintain linear AS-AD equations throughout the paper. As regards aggregate-supply, Dolado *et al.* (2005) can only reject linearity at 10 percent, in a preliminary analysis with exogenously computed gaps, while Aguiar and Martins (2005b) offer compelling evidence in favour of linearity of the Phillips curve for various samples in the Euro Area, using model-consistent unemployment gaps.

proxy for exogenous supply shocks - *SS*, in percentage points – is the lagged difference between imported and domestic inflation, with imported inflation computed as 400 times the first difference of the log of the Area's import deflator (*MTD*). The output gap - *y*, in percentage points - is the actual quarterly real GDP (*YER*) minus a stochastic trend real output.

The output gap has been estimated by the authors from a univariate unobservable components model of log real output, specifically a local linear trend model augmented with an autoregressive cycle. As the maximum likelihood estimate of the variance of the innovation to the stochastic drift in the trend – output's trend growth rate – is biased towards zero, we employ Stock and Watson's (1998) procedure to obtain a median unbiased estimation of this variance, and then constrain the kalman filter estimation of the trend-cycle model accordingly.[4] The output gap time-series here used is not the estimate given by the end-of-sample kalman smoother, but rather is the series of updated one-step-ahead forecasts given directly by the kalman filter (see Harvey, 1989). This *quasi-real-time* estimate is closer to the information available to policy-makers at the time policy decisions had to be made than the two-sided output gaps that have been used in the tests for asymmetry of policy preferences in the literature so far, and thus should allow for a better estimation of (possibly asymmetric) central bank preferences.

It could be argued that, to agree with the ECB's definition of price stability, the inflation rate, π, should not be the growth rate of the GDP deflator but rather that of the harmonized index of consumer prices (HICP). Our choice is due to two reasons. First, because the HICP is the only series of the AWM database that is not seasonally adjusted, we would have to adjust ourselves that series for its seasonality, most likely creating biases that could affect the results. Second, because π must relate closely to both the policy decisions and, in the aggregate supply equation, to the output gap, GDP deflator inflation is a more adequate indicator of inflation than the HICP.[5] The sample average of π, 1.92 percent, is quite close to the average of the analogous rate of growth

---

[4] Specifically, the *sup* of the F tests for structural break in the quarterly growth rate of real output, the QLR test statistic, is 18.3455, which from Stock and Watson's (1998, table 3 page 354) yields a coefficient λ of 13.95174, that divided by the number of observations (139) results in a I(2)/I(1) signal-to-noise ratio of 0.1010996. Notice that the output gap is estimated with the whole available time-series of real output, 1970:I-2004:III, even though only gaps for 1995:I-2004:III are used in the subsequent estimations in the paper. All data and replication files are available from the authors upon request, including the Gauss codes for computing the output gap used as data in this paper.

[5] This second argument is, indeed, parallel to the reason that lies behind the standard use of a 3-month interest rate instead of a shorter money market rate, which would be closer to the actual policy instrument - the fact that *i* must, in this class of models, simultaneously play the role of policy instrument and connect closely to aggregate demand decisions.

of the HICP, 1.89 percent, while the volatility of the HICP inflation is considerably larger than that of π, surely due to the seasonality of the former.

Following the standard assumptions in the empirical literature of monetary policy, the policy-maker's preferences are modeled as an inter-temporal loss functional in which, at each period, the loss function features the square of the deviations of inflation and the output gap from desired levels (π* and zero, respectively), as well as the square of the change in the interest rate, which is the policy instrument. Future values are discounted at rate δ, and the weights ϕ, λ, and μ are nonnegative.

$$L_t = E_t \sum_{\tau=0}^{\infty} \delta^{\tau} \frac{1}{2}\left[\phi(\pi_{t+\tau} - \pi^*)^2 + \lambda y_{t+\tau}^2 + \mu(i_{t+\tau} - i_{t+\tau-1})^2\right] \qquad (2)$$

Assuming a discretionary policy regime, for the sake of realism and estimation feasibility, the optimization problem solved by the central banker is a closed-loop system: at each period, given the observed state of the economy, the policy-maker chooses the value for the policy control variable - the interest rate i - that minimizes the loss functional, subject to the dynamic structure of the economy:

$$Min(L_t) = \underset{i_t}{Min}\, E_t \sum_{\tau=0}^{\infty} \delta^{\tau} \frac{1}{2}\left[\phi(\pi_{t+\tau} - \pi^*)^2 + \lambda y_{t+\tau}^2 + \mu(i_{t+\tau} - i_{t+\tau-1})^2\right], \quad \forall t \qquad (3)$$

subject to system (1).

Asymmetry in the policy-maker's preferences means that the structural weights ϕ, λ, and μ are not constant but rather are functions of the state of the economy or policy. Restricting these functions to simple threshold (bilinear) models, the forms of asymmetric preferences suggested in the literature may be written as in expression (4), respectively for (Cukierman's) precautionary demand for expansions, (Goodhart's 1998) precautionary demand for price stability, and (Goodhart's 1997) interest rate smoothing asymmetry:

$$\begin{aligned}
\lambda &= \lambda\,|_{[y_{t+\tau}\geq 0]} \times 1_{[y_{t+\tau}\geq 0]} + \lambda\,|_{[y_{t+\tau}<0]} \times 1_{[y_{t+\tau}<0]} \\
\phi &= \phi\,|_{[\pi_{t+\tau}\geq \pi^*]} \times 1_{[\pi_{t+\tau}\geq \pi^*]} + \phi\,|_{[\pi_{t+\tau}<\pi^*]} \times 1_{[\pi_{t+\tau}<\pi^*]} \\
\mu &= \mu\,|_{[\Delta i_{t+\tau}\geq 0]} \times 1_{[\Delta i_{t+\tau}\geq 0]} + \mu\,|_{[\Delta i_{t+\tau}<0]} \times 1_{[\Delta i_{t+\tau}<0]}
\end{aligned} \qquad (4)$$

where $1_{[.]}$ is a Heaviside function that equals unity if the argument-condition holds, and zero otherwise. Under (4), the loss function (2) turns into a threshold quadratic function in which the weights associated to the squared deviations of each goal-variable from its desired level are allowed to switch when each goal-variable is expected to be above or below its desired level. The policy-maker's optimization problem is, now, to choose the interest rate – *i*, the policy instrument - at each period – *t* - so that the threshold quadratic loss function is minimized through infinity subject to (1), *i.e.*:

$$Min(L_t) = \underset{i_t}{Min} E_t \sum_{\tau=0}^{\infty} \delta^{\tau} \frac{1}{2} \Big\{ \big(\phi \,|_{[\pi_{t+\tau} \geq \pi^*]} \times 1_{[\pi_{t+\tau} \geq \pi^*]} + \phi \,|_{[\pi_{t+\tau} < \pi^*]} \times 1_{[\pi_{t+\tau} < \pi^*]} \big) (\pi_{t+\tau} - \pi^*)^2$$

$$+ \big(\lambda \,|_{[y_{t+\tau} \geq 0]} \times 1_{[y_{t+\tau} \geq 0]} + \lambda \,|_{[y_{t+\tau} < 0]} \times 1_{[y_{t+\tau} < 0]} \big) (y_{t+\tau})^2 \tag{5}$$

$$\big(\mu \,|_{[\Delta i_{t+\tau} \geq 0]} \times 1_{[\Delta i_{t+\tau} \geq 0]} + \mu \,|_{[\Delta i_{t+\tau} < 0]} \times 1_{[\Delta i_{t+\tau} < 0]} \big) (i_{t+\tau} - i_{t+\tau-1})^2 \Big\}$$

s.t. (1).

For example, if the policy-maker has a precautionary demand for expansions, then $\lambda|[y_{t+\tau} \geq 0] < \lambda|[y_{t+\tau} < 0]$, and he would change interest rates - at moment t - more aggressively when he expected the output gap to be - at moment $t+\tau$ - below zero, than when he expected it to be positive, for the same size of deviation from zero.

This specification nests the symmetric case, in which we would be back at constant weights ϕ , λ, and μ, and is flexible in the sense that it allows for modeling asymmetrically the loss function weights simultaneously or individually, thus permitting a clarification of the origin of any asymmetry implicit in the data. In addition, even though the economically interesting hypothesis state that each weight would change when the associated variable surpasses the relevant target (or desired level) the framework may be carried out cross-checking the evidence of asymmetry with virtually all possible alternative combinations of threshold variables. The choice of a simple bilinear model is motivated by the aim of keeping the loss function and the corresponding Euler equation as simple as possible; this seems the sensible attitude in view of the limited of data available in the sample and, also, in view of the lack of a-priori information about the functional form of the possible asymmetry.[6]

The Euler equation for this problem is the following expression describing the optimal path for the policy instrument, i¸ as function of the expected values of the state variables of the economy, π and y:

---

[6] One functional form often used in the recent literature, the *linex* function – see Nobay and Peel (2003) and Ruge-Murcia (2004) – behaves quite similarly to our threshold quadratic specification for realistic parameters, but results in a more complex Euler equation and could lead to empirical problems due to the limitations of the data sample.

$$E_t \sum_{\tau=0}^{\infty} \delta^{\tau} \left(\phi |_{[\pi_{t+\tau} \geq \pi^*]} \times 1_{[\pi_{t+\tau} \geq \pi^*]} + \phi |_{[\pi_{t+\tau} < \pi^*]} \times 1_{[\pi_{t+\tau} < \pi^*]} \right) \left[(\pi_{t+\tau} - \pi^*) \frac{\partial \pi_{t+\tau}}{\partial i_t} \right]$$

$$+ E_t \sum_{\tau=0}^{\infty} \delta^{\tau} \left(\lambda |_{[y_{t+\tau} \geq 0]} \times 1_{[y_{t+\tau} \geq 0]} + \lambda |_{[y_{t+\tau} < 0]} \times 1_{[y_{t+\tau} < 0]} \right) \left[y_{t+\tau} \frac{\partial y_{t+\tau}}{\partial i_t} \right] \tag{6}$$

$$+ \left(\mu |_{[\Delta i_{t+0} \geq 0]} \times 1_{[\Delta i_{t+0} \geq 0]} + \mu |_{[\Delta i_{t+0} < 0]} \times 1_{[\Delta i_{t+0} < 0]} \right) (i_t - i_{t-1})$$

$$- \left(\mu |_{[\Delta i_{t+1} \geq 0]} \times 1_{[\Delta i_{t+1} \geq 0]} + \mu |_{[\Delta i_{t+1} < 0]} \times 1_{[\Delta i_{t+1} < 0]} \right) \delta E_t (i_{t+1} - i_t) = 0$$

Because of the persistence in the AS-AD system, the Euler equation has an infinite horizon, and thus cannot be used directly in empirical work. With this regard, we adopt the approach devised by Favero and Rovelli (2003) and used by Aguiar and Martins (2005a), and truncate expression (6) at 4 quarters ahead. This horizon seems realistic, in view of the ability of forecasting macro-economic conditions by actual policymakers - see Aguiar and Martins (2005a) for further discussions and sensitivity analysis. The specification proceeds with expanding the partial derivatives in (6), and writing these as functions of the relevant AS-AD coefficients in (1). Then, with equation (6) including the cross-equation restrictions that ensure the minimization of the policy-maker's loss function subject to the constraints given by the structure of the economy, the resulting expression is supplemented with an innovation, and develops into (7):

$$E_t \delta^3 \left(\phi |_{[\pi_{t+3} \geq \pi^*]} \times 1_{[\pi_{t+3} \geq \pi^*]} + \phi |_{[\pi_{t+3} < \pi^*]} \times 1_{[\pi_{t+3} < \pi^*]} \right) \left[(\pi_{t+3} - \pi^*) \right] \left[c_9 . c_5 \right]$$

$$+ E_t \delta^4 \left(\phi |_{[\pi_{t+4} \geq \pi^*]} \times 1_{[\pi_{t+4} \geq \pi^*]} + \phi |_{[\pi_{t+4} < \pi^*]} \times 1_{[\pi_{t+4} < \pi^*]} \right) \left[(\pi_{t+4} - \pi^*) \right] \left[c_9 . c_2 . c_5 + c_6 . c_9 . c_5 \right]$$

$$+ E_t \delta^3 \left(\lambda |_{[y_{t+3} \geq 0]} \times 1_{[y_{t+3} \geq 0]} + \lambda |_{[y_{t+3} < 0]} \times 1_{[y_{t+3} < 0]} \right) \left[y_{t+3} \right] \left[c_5 \right] \tag{7}$$

$$+ E_t \delta^4 \left(\lambda |_{[y_{t+4} \geq 0]} \times 1_{[y_{t+4} \geq 0]} + \lambda |_{[y_{t+4} < 0]} \times 1_{[y_{t+4} < 0]} \right) \left[y_{t+4} \right] \left[c_2 . c_5 \right]$$

$$+ \left(\mu |_{[\Delta i_{t+0} \geq 0]} \times 1_{[\Delta i_{t+0} \geq 0]} + \mu |_{[\Delta i_{t+0} < 0]} \times 1_{[\Delta i_{t+0} < 0]} \right) (i_t - i_{t-1})$$

$$- \left(\mu |_{[\Delta i_{t+1} \geq 0]} \times 1_{[\Delta i_{t+1} \geq 0]} + \mu |_{[\Delta i_{t+1} < 0]} \times 1_{[\Delta i_{t+1} < 0]} \right) \delta E_t (i_{t+1} - i_t) + \varepsilon_t^{IR} = 0$$

The econometric framework then consummates with simultaneous estimation of the system of 3 equations composed of the AS-AD system (1) and the Euler equation (7), generating estimates of the parameters describing the monetary policy regime as well as of the AS-AD coefficients and the system's innovations. Because expectations of future inflation, output gaps, and interest rates are not available in the data, they are replaced by actual observations and therefore estimation is conducted with the generalized method of moments (GMM). This strategy is based on the assumption that the policy-maker forms rational expectations of future inflation, the output gap, and interest rates, in the sense that the policy-maker's expectation errors are not correlated with the information available when forming expectations. As regards the instrument set to form the orthogonality conditions, we follow Aguiar and Martins (2005a) and use the second, third and fourth lags of all the system's variables as instruments, and base inference in a heteroescedasticity and auto-correlation-consistent variance-covariance matrix, maintaining these features of the estimator throughout all the empirical work for the sake of comparability.[7]

In order to be operational, and have economic meaning, the framework for testing loss function asymmetry requires setting the inflation target, π*, consistent with the policy-maker's desired level of inflation. In view of the definition of price stability by the ECB, reviewed above, a value of 2 percent for π* is a consensual choice; this target has been used, in recent literature, by Dolado *et al.* (2005) and by Surico (2003).

With the aim of achieving clear evidence on all types of asymmetry in the policy-maker's preferences identified in the literature, estimation is carried out sequentially allowing each of the loss function weights ϕ , λ, and μ to vary with the state of the corresponding target variable, and then concludes with a joint test of the possible asymmetries. Statistical inference is based on individual significance tests and *Wald* tests for the null hypothesis of equality of the relevant coefficients in the two positions of the policy variables, above and below the target. In agreement with the standard practice in the literature, the weight ϕ is restricted to ϕ=1 when not allowed to be asymmetric; likewise, when this coefficient is allowed to be asymmetric, the sum of $\phi|[\pi_{t+\tau} \geq \pi *]$ and $\phi|[\pi_{t+\tau} < \pi *]$ is restricted to equal 2, so that under the null of symmetry $\phi|[\pi_{t+\tau} \geq \pi *]$=$\phi|[\pi_{t+\tau} < \pi *]$=1.

[7] The system is first pre-whitened, and then a Bartlett Kernel is used to weight the auto-covariances, with a Andrews estimator of the bandwith. The specific GMM estimator employed is the one-step weighting matrix estimator.

4. Results

In this section we conduct the tests for asymmetry in the policy-maker's loss function, and assess the results, including a comparison of the asymmetric preferences results with those of a standard quadratic central bank loss function.

Figure 1 shows, for the sample period (1995:I-2004:III), the variables that may be relevant arguments in the policy-maker's loss function, together with the corresponding desired values, which are the threshold levels in the asymmetry tests – 0 for y and Δi, and 2 for π.

Table 1 summarizes the tests for each asymmetry - precautionary demand for expansions, precautionary demand for price stability and asymmetric interest rate smoothing – as well as the joint test of all these asymmetries. In order to conserve space, we report only the loss function coefficients, and their test statistics, even though these have been obtained in a joint GMM estimation of the AS-AD-Euler system, as discussed in section 3.

The table shows no sign of precautionary demand for expansions, as neither $\lambda|[y_{t+\tau} \geq 0]$ nor $\lambda|[y_{t+\tau} < 0]$ are statistically significant nor the hypothesis that $\lambda|[y_{t+\tau} \geq 0]$=$\lambda|[y_{t+\tau} < 0]$ can be rejected at conventional significance levels, irrespectively of modeling this type of asymmetry alone or in association to other asymmetry.

Moreover, the evidence indicates that the output gap, y, is not a relevant argument in the Euro Area's policy-maker loss function, as λ is statistically insignificant not only when some source of loss function asymmetry is allowed for, but also (results not reported) when the loss function abides by the standard quadratic form.

When, in accordance with this evidence, regimes of strict inflation targeting are adopted – restricting λ=0 – there is evidence in favor of the hypothesis of precautionary demand for price stability. In fact, the hypothesis that $\phi|[\pi_{t+\tau} \geq \pi^*]$=$\phi|[\pi_{t+\tau} < \pi^*]$ can be rejected at 5 percent of significance, and the estimates for $\phi|[\pi_{t+\tau} \geq \pi^*]$, 1.354, and $\phi|[\pi_{t+\tau} < \pi^*]$, 0.646, mean that the policy-maker has weighted deviations of inflation above 2 percent twice as much as deviations of inflation below 2 percent.

While combining an asymmetry regarding the objective of price stability with possible interest rate smoothing asymmetry increases the p-value of the test of the former to 8 percent, the estimates of $\phi|[\pi_{t+\tau} \geq \pi^*]$ and $\phi|[\pi_{t+\tau} < \pi^*]$ keep virtually unchanged. As regards the interest rate smoothing asymmetry itself, there is no evidence in favor of this type of asymmetry throughout the whole table 2, as the *wald* statistic for the hypothesis that $\mu|[\Delta i_{t+\tau} \geq 0] = \mu|[\Delta i_{t+\tau} < 0]$ can never be deemed statistically significant, and, indeed, allowing for different μ for periods of rate increases and decreases turns out to generate very imprecise estimates of these parameters.

In short, during 1995:I-2004:III the policy actions of the Euro Area monetary policy-maker reveal a regime of strict inflation targeting with interest rate smoothing and a precautionary demand for price stability.[8] The evidence from our framework is in sharp contrast with Surico's (2003) inference that the ECB has had a precautionary demand for expansions; the contrast could be due to the difference in sample period (monthly data for 1997:7-2002:10), but could also be related to more substantive matters such as differences in the computation of the gap (two-sided Hodrick-Prescott-filter of industrial production) or in the underlying structural macro model (a purely forward-looking AS-AD model).

Table 2 presents complete estimates of the selected model, in the upper panel, together with those of the parallel model with standard quadratic policy preferences, in the lower panel; the case of flexible inflation targeting – λ not restricted to 0 but constant - is not reported because of the insignificance of λ found above (also found by Aguiar and Martins, 2005a, with an alternative measure of the output gap).

The key coefficients of the structural equations – the aggregate-demand and aggregate-supply slopes, c_5 and c_9, representing the sensitivities of the gap to the real interest rate and of inflation to the output gap - are estimated with the expected signs, reasonable magnitudes, and quite good precision. The whole set of AS-AD coefficients is virtually identical across the two models of distinct loss function shapes, which also happens to the real equilibrium interest rate – given by $c_1/(-\ c_5)$ -, which is estimated at around 1.25 percent.

The estimate of the relative weight of interest rate smoothing, μ, is somewhat larger in the model with precautionary demand for price stability (0.0028 against 0.0020) and is more precisely estimated, having a smaller p-value (0.021 against 0.06). In the model of quadratic preferences the inflation target is estimated at 1.787 percent, and its 95 percent confidence interval comprises inflation rates between 1.65 and 1.92 percent, which is consistent with the ECB's definition of price stability and with the

---

[8] The asymmetry tests results have proven to be robust to a cross-check consisting of testing for asymmetry in each loss function coefficient using as threshold variable all possible alternative target-variables in the loss function.

asymmetry that we have found - as the confidence interval does not comprise 2 percent. Another sign of the statistical relevance of the asymmetry is the decline in the standard error of the Euler equation from the quadratic to the asymmetric model (while the standard errors of regression of the AS and AD equations are practically unchanged).

Figures 2 and 3 further assess the results, essentially inspecting the economic relevance of the detected asymmetry in preferences.

Figure 2 shows the degree of asymmetry implicit in the estimated model of strict inflation targeting with interest rate smoothing and precautionary demand for price stability, weighted against the symmetry of the quadratic specification. The figure depicts the instantaneous loss function values both of the asymmetric model (centered around π*=2) and of the quadratic model (centered in π* =1.787) - computed for each pair of π and Δi observed in each quarter of the sample. The asymmetry is of a moderate size but is evident: in contrast to what is seen in the first chart around 1.787, in the second chart of the figure negative deviations of π from 2 percent generate smaller increases in the loss than do positive deviations of the same absolute value.

Figure 3 depicts the actual interest rate together with the paths of this variable generated by dynamically solving each of the models - symmetric and asymmetric strict inflation targeting with interest rate smoothing (with asymmetric standing for precautionary demand for price stability). The dynamic solutions are multi-step forecasts using actual data prior to 1995:I for lagged endogenous variables (y, π, and i) and the model's forecasts thereafter. Clearly, both models are stable, but the model with asymmetry, in the form of a precautionary demand for price stability, mimics much more closely the actual course of interest rates. In fact, the root of the mean squared error (RMSE) of this model is merely 64.5 percent that of the symmetric model.

5. Concluding Remarks

This paper has tested for asymmetries in the preferences of the aggregate Euro Area monetary policy-maker, looking at deviations from the standard quadratic loss function that have been suggested in recent literature - precautionary demand for expansions, precautionary demand for price stability, and interest rate smoothing asymmetry.

The paper has adopted a baseline framework used in recent research on the preferences of the Euro Area monetary policy-maker. In particular, the macro-economy structure has been modeled with a data-consistent AS-AD system of the Rudebusch-

Svensson style, the sample period has been set at 1995:I (4 years before the actual European Monetary Union, EMU), and the econometric strategy has been based on simultaneous GMM estimation of the AS, AD and an empirical policy-maker's Euler equation describing optimal policy under discretion.

The baseline framework has been improved by re-specifying the central bank's loss function allowing for weights with possibly different values when the corresponding target variable is above and below its desired value. It has been shown that the resulting threshold (bilinear) Euler equation can be estimated by GMM jointly with the macro structure to get estimates of the whole model structural coefficients, allowing for tests of the relevant asymmetries discussed in the literature, conditional on a known inflation target.

A step forward has been achieved in the gathering of the literatures of asymmetry in policy-makers' preferences and of the use of *real-time* data in policy analysis, with the use of a measure of *quasi-real-time* output gap that should be closer to the information available to policy-makers when deciding policy than the two-sided filters routinely used in the related literature.

Two main results have been obtained in this asymmetric framework. First, flexible inflation targeting by the Euro-Area policy-maker is rejected in favor of strict inflation targeting, which corroborates previous results obtained under symmetry. Second, there is evidence that the Euro-Area monetary policy-maker has had a Goodhart's precautionary demand for price stability throughout 1995-2004, weighting deviations of inflation above 2 percent twice as much as deviations of inflation below 2 percent. This asymmetry is consistent with the Euro Area policy-maker's mandate and definition of price stability, as well as with the predictable building of credibility pursued by a recently created central bank. Our results seem, with this regard, more convincing than other elsewhere in the literature that surprisingly detected a Cukierman's precautionary demand for expansions.

This paper's evidence of asymmetry in the aggregate Euro Area policy-maker's preferences should obviously be put to test once enough new data allow for the estimation of strictly post-1999 monetary policy preferences with acceptable degrees of freedom, and once truly *real-time* vintages of information reported by the ECB may be used as data.

References

Aguiar, Alvaro, and Manuel M. F. Martins. (2005b) "Testing the Significance and the Non-linearity of the Phillips Trade-off in the Euro Area," forthcoming *Empirical Economics*.

Aguiar, Alvaro, and Manuel M. F. Martins. (2005a) "The Preferences of the Euro Area Monetary Policy-maker," *Journal of Common Market Studies*, Vol. 43, No. 2, June, 221-50.

Bec, Frédérique, Mélika Ben Salem, and Fabrice Collard. (2002) "Asymmetries in Monetary Policy Reaction Function: Evidence for US, French and German Central Banks," *Studies in Nonlinear Dynamics & Econometrics*, Vol. 6, No. 2, July, article 3.

Blinder, Alan S. (1998) *Central Banking in Theory and Practice*, Lionel Robbins Lectures, (Cambridge and London: MIT Press).

Bruinshoofd, Allard, and Bertrand Candelon (2005) "Nonlinear monetary policy in Europe: fact or myth?" *Economics Letters*, Vol. 86, No. 3, March, 399-403.

Cukierman, Alex. (2000) "The Inflation Bias Result Revisited," *Mimeo*, Berglas School of Economics, Tel-Aviv University, April 25th.

Cukierman, Alex. (2002) "Are Contemporary Central Banks Transparent about Economic Models and Objectives and What Difference Does It Make?" *Federal Reserve Bank of St. Louis Review*, Vol. 84, No. 4, July-August, 15-35.

Cukierman, Alex, and Stefan Gerlach. (2003) "The Inflation Bias Revisited: Theory and Some International Evidence," *Manchester School*, Vol. 71, No. 5, September, 541-65.

Cukierman, Alex, and Anton Muscatelli. (2002) "Do Central Banks have Precautionary Demands for Expansions and for Price Stability?" CESIFO Working Paper nº 764, August.

Dolado, Juan, Ramón Maria-Dolores, and Manuel Naveira. (2005) "Are Monetary Policy Reaction Functions Asymmetric? The Role of Nonlinearity in the Phillips Curve, " *European Economic Review,* Vol. 49, No. 2, February, 485-503.

Dolado, Juan, Ramón Maria-Dolores, and Francisco Ruge-Murcia. (2004) "Non-Linear Monetary Policy Rules: Some New Evidence for the US," *Studies in Nonlinear Dynamics and Econometrics,* Vol. 8, No. 3, September, Article 2.

European Central Bank.(2004) *The Monetary Policy of the ECB*, (Frankfurt: European Central Bank), 2nd edition.

Favero, Carlo A., and Ricardo Rovelli. (2003) "Macroeconomic Stability and the Preferences of the Fed: A Formal Analysis, 1961-98," *Journal of Money, Credit, and Banking*, Vol. 35, No. 4, August, 545-56.

Fischer, Stanley. (1994) "Modern Central Banking", pp. 262-308 *in* Forrest Capie *et al.* (Eds), *The future of central banking: the tercentenary symposium of the Bank of England*, (Cambridge; New York and Melbourne: Cambridge University Press).

Gerlach, Stefan. (2003) "Recession Aversion, Output and the Kydland-Prescott Barro-Gordon Model," *Economics Letters*, 81 (3), December 2003, 389-94.

Goodhart, Charles A. E.. (1998) "Central Bankers and Uncertainty", London School of Economics, Financial Markets Group Special Paper Series no. 106, October.

Goodhart, Charles A. E.. (1997) "Why Do the Monetary Authorities Smooth Interest Rates?" pp. 119-74 *in* Stefan Collignon (Ed.), *European monetary policy*, (London and Washington D.C.: Pinter).

Harvey, Andrew C. (1989) *Forecasting, Structural Time Series Models and the Kalman Filter* (Cambridge: Cambridge University Press).

Karagedikli, Özer, and Kirdan Lees, (2004) "Do Inflation Targeting Central Banks Behave Asymmetrically? Evidence from Australia and New Zealand," Reserve Bank of New Zealand Discussion Paper nº 2004/02, April.

Kim, Dong H., Denise R. Osborn, and Marianne Sensier. (2002) "Nonlinearity in the Fed's Monetary Policy Rule," Centre for Growth & Business Cycle Research Discussion Paper nº 018, October, forthcoming *Journal of Applied Econometrics*.

Martin, Christopher, and Costas Milas. (2004) "Modelling Monetary Policy: Inflation Targeting in Practice," *Economica*, Vol. 71, No. 282, May, 209-21.

Nobay, A. Robert, and David A. Peel. (2003) ”Optimal Discretionary Monetary Policy in a Model of Asymmetric Central Bank Preferences,” *Economic Journal*, Vol. 113, No. 489, July, 657-65.

Ruge-Murcia, Francisco J. (2004) “The Inflation Bias When the Central Bank Targets the Natural Rate of Unemployment,” *European Economic Review*, Vol. 48, No. 1, February, 91-107.

Ruge-Murcia, Francisco J. (2003b) “Inflation Targeting under Asymmetric Preferences,” *Journal of Money, Credit, and Banking*, Vol. 35, No. 5, October, 763-85.

Ruge-Murcia, Francisco J. (2003a) “Does the Barro-Gordon Model Explain the Behavior of US Inflation? A Reexamination of the Empirical Evidence,” *Journal of Monetary Economics*, 50 (6), September, 1375-90.

Stock, James, and Mark Watson. (1998) "Median Unbiased Estimation of a Coefficient Variance in a Time-Varying Parameter Model," *Journal of the American Statistical Association,* Vol. 93, No. 441, March, 349-358.

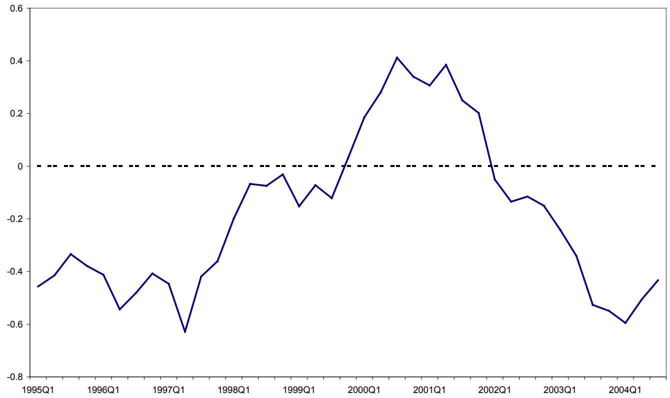
Surico, Paolo. (2004) “Inflation Targeting and Nonlinear Policy Rules: the Case of Asymmetric Preferences,” CESIFO Working Paper nº 1280, September.

Surico, Paolo. (2003) “Asymmetric Reaction Functions for the Euro Area,” *Oxford Review of Economic Policy*, Vol. 19, No. 1, Spring, 44-57.

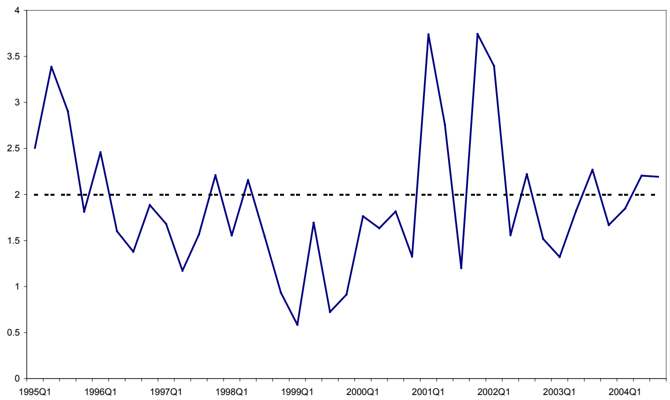
Figure 1. Loss Function Variables

Euro Area 1995:I-2004:III

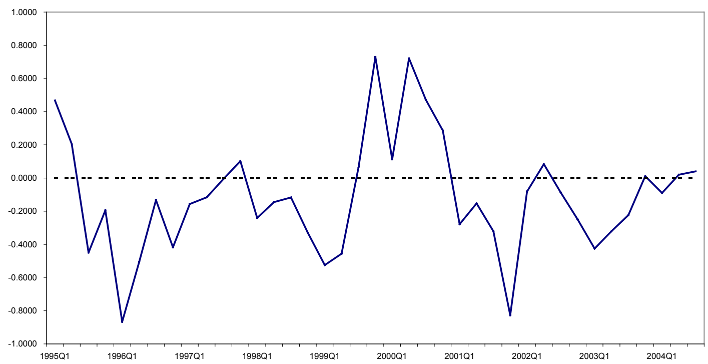
Output Gap



Inflation



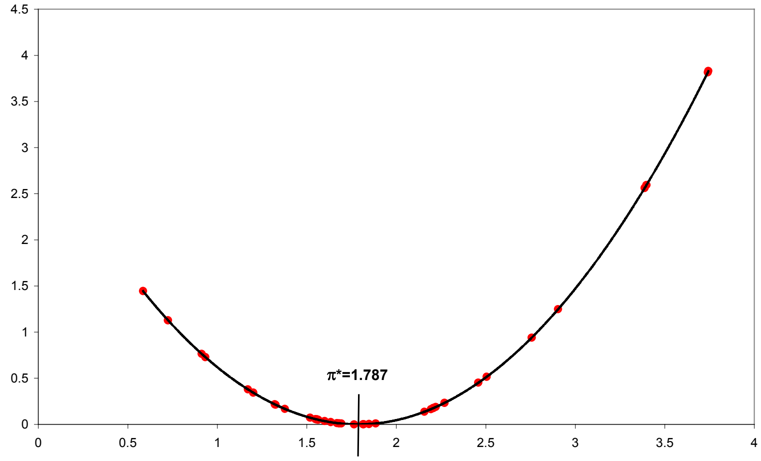
Interest rate changes



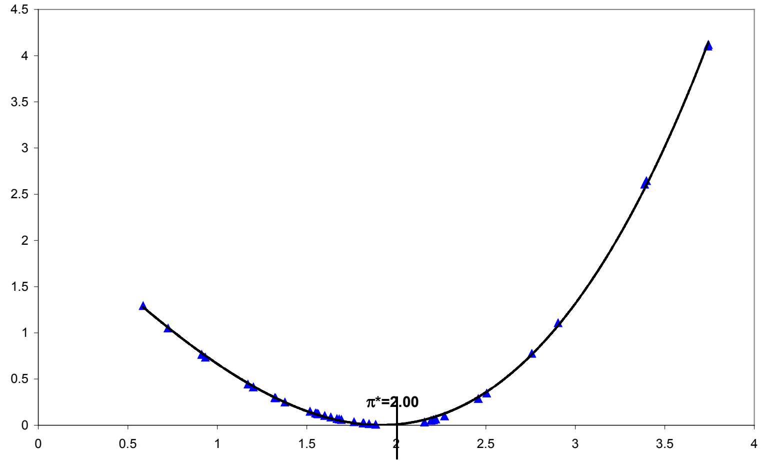
Notes: Data sources - Area Wide Model Database AWM12up5, ECB, August 2004 (1995:I-2003:IV) and ECB Monthly Bulletin December 2004 (2004:I – III), and authors' calculations.
Output gap – cycle from univariate unobserved components model (local linear trend model with autoregressive cycle) of log real GDP 1970:I-2004:III, estimated with the kalman filter with Stock and Watson's (1998) median unbiased estimation of the variance of the trend stochastic drift.
Inflation – $400*\ln(P_t/P_{t-1})$, where P is the GDP deflator.
Interest Rate changes - i_t-i_{t-1} where i is the 3-month interest rate.
Dotted lines - targets.

Figure 2. Central Bank's Loss
Euro Area 1995:I-2004:III

Symmetric Loss Function (π*=1.787)



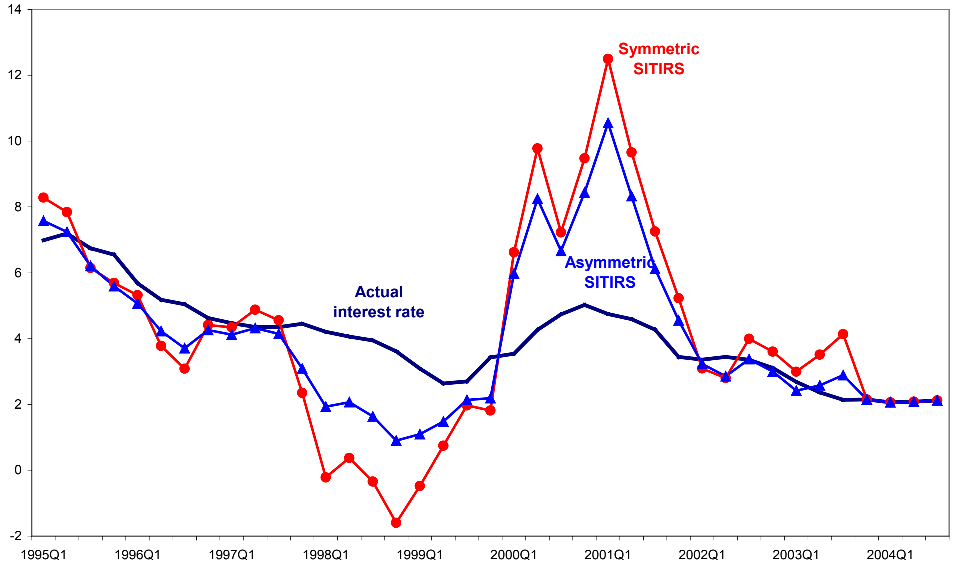
Asymmetric Loss Function (π*=2.00)



Notes: Symmetric Loss Function (π*=1.787) – Actual instantaneous policy-maker's loss implied by each quarter's inflation and interest rate changes, given the policy regime estimated under symmetric preferences and unrestricted inflation target (last panel of table 2: strict inflation targeting with interest rate smoothing).

Asymmetric Loss Function (π*=2.00) – Actual instantaneous policy-maker's loss implied by each quarter's inflation and interest rate changes, given the estimated policy regime with precautionary demand for price stability (first panel of table 2: strict inflation targeting with interest rate smoothing and precautionary demand for price stability, given the target of 2-percent inflation).

Figure 3. Fitted and Actual Interest Rate
Euro Area 1995:I-2004:III



Notes: Symmetric SITIRS - Interest rates given by the dynamic solution of the AD-AS-Euler model shown in the last panel of table 2, corresponding to a policy regime of strict inflation targeting with interest rate smoothing, symmetric weights in the policy-maker's loss function and inflation target estimated at 1.787 percent.

Asymmetric SITIRS - Interest rates given by the dynamic solution of the AD-AS-Euler model shown in the first panel of table 2, corresponding to a policy regime of strict inflation targeting with interest rate smoothing with precautionary demand for price stability, given an inflation target of 2 percent.

Table 1. Tests for Asymmetries in the Preferences of the Monetary Policy-maker
Euro Area 1995:I – 2004:III

	Parameter Estimates (P-values)									Test Statistics (P-values)		
	ϕ	$\phi\|_{\pi\geq 2}$	$\phi\|_{\pi<2}$	λ	$\lambda\|_{y\geq 0}$	$\lambda\|_{y<0}$	μ	$\mu\|_{\Delta i\geq 0}$	$\mu\|_{\Delta i<0}$	$\phi\|_{\pi\geq 2} = \phi\|_{\pi<2}$	$\lambda\|_{y\geq 0} = \lambda\|_{y<0}$	$\mu\|_{\Delta i\geq 0} = \mu\|_{\Delta i<0}$
I. Precautionary Demand	1.0				-0.193	-0.184	0.001				0.000	
For Expansions					(0.75)	(0.21)	(0.45)				(0.99)	
II. Precautionary Demand		2.019	-0.019	0.152			0.002			0.598		
for Price Stability		(0.13)	(0.99)	(0.63)			(0.24)			(0.44)		
		1.354	0.646				0.003			3.758		
		(0.00)	(0.00)				(0.02)			(0.05)		
III. Asymmetry in Interest	1.0			-0.161				-0.004	0.004			0.288
Rate Smoothing				(0.24)				(0.70)	(0.42)			(0.59)
	1.0							-0.002	0.005			0.552
								(0.73)	(0.17)			(0.46)
IV. Joint asymmetries		2.948	-0.948		-0.306	0.359		0.005	0.002	0.345	0.300	0.053
		(0.37)	(0.78)		(0.75)	(0.57)		(0.63)	(0.68)	(0.56)	(0.58)	(0.82)
		1.347	0.653					0.003	0.003	3.122		0.003
		(0.00)	(0.00)					(0.67)	(0.52)	(0.08)		(0.96)

Notes: The reported estimates stem from joint estimations of the Policy-maker's Euler equation (truncated at 4-quarters-leads) and the aggregate demand-aggregate supply structure, with the adequate cross-equations restrictions and with the inflation target π^* set to 2 percent. The discount factor is $\delta = 0.975$.
The AD-AS coefficients are omitted for space conservation. The asymmetry tests statistics in the last three columns are Wald statistics for the indicated null hypothesis.
GMM estimator – one-step weighting matrix, fully iterated parameters. HAC variance-covariance matrix - pre-whitening, Bartlett kernel, Andrews bandwidth.
Instruments - constant, $\Delta\pi_{t-i}$, x_{t-i}, i_{t-i}, $Im\pi_{t-i}$, i=2, 3, 4.

Table 2. Asymmetric *vs* Symmetric Policy-maker's Preferences and Macroeconomic Structure
Euro Area 1995:I – 2004:III

Strict Inflation Targeting with Interest Rate Smoothing and Precautionary Demand for Price Stability

AD	**c1**	**c2**	**c3**	**c4**	**c5**	$\sigma(\varepsilon^{AD})$
	0.015	1.448	-0.384	-0.121	-0.012	0.111
	(0.178)	(0.000)	(0.044)	(0.244)	(0.002)	
AS	**c6**	**c7**	**c8**	**c9**	**c10**	$\sigma(\varepsilon^{AS})$
	0.568	-0.109	0.710	0.324	0.060	0.683
	(0.006)	(0.253)	(0.000)	(0.003)	(0.000)	
CB Loss	π^*	$\phi\|_{\pi \geq 2}$	$\phi\|_{\pi < 2}$	μ	**r***	$\sigma(\varepsilon^{IR})$
	2.000	1.354	0.646	0.0028	1.244	0.007
	--	(0.000)	(0.001)	(0.021)		

Strict Inflation Targeting with Interest Rate Smoothing

AD	**c1**	**c2**	**c3**	**c4**	**c5**	$\sigma(\varepsilon^{AD})$
	0.017	1.449	-0.348	-0.154	-0.013	0.111
	(0.137)	(0.000)	(0.066)	(0.124)	(0.001)	
AS	**c6**	**c7**	**c8**	**c9**	**c10**	$\sigma(\varepsilon^{AS})$
	0.587	-0.123	0.719	0.331	0.060	0.685
	(0.001)	(0.258)	(0.000)	(0.001)	(0.000)	
CB Loss	π^*	ϕ	λ	μ	**r***	$\sigma(\varepsilon^{IR})$
	1.787	1.000	--	0.0020	1.268	0.008
	(0.000)	---	--	(0.060)		

Notes: The table reports results from the joint estimations of the aggregate demand-aggregate supply structure and the Policy-maker's Euler equation (truncated at a 4-quarters-lead), for Loss functions of strict inflation targeting with interest rate smoothing with and without asymmetry in the targeting of inflation, respectively, (with the adequate cross-equations restrictions in each set of Euler-AD-AS equations).

Number in parenthesis are p-values. Discount factor - $\delta = 0.975$.

GMM estimator – one-step weighting matrix, fully iterated parameters.

HAC variance-covariance matrix - pre-whitening, Bartlett kernel, Andrews bandwidth.

Instruments - constant, $\Delta\pi_{t-i}$, x_{t-i}, i_{t-i}, $Im\pi_{t-i}$, $i=2, 3, 4$.