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On the Robustness of the "Taylor Rule" in the EMU

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On the robustness of the "Taylor Rule" in the EMU

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Abstract

Following a policy rule mechanically when operating monetary policy is neither realistic nor practical. Nevertheless, monetary policy rules have received a great deal of attention in recent macroeconomic research. The paper focuses on a famous interest rate rule, namely the Taylor Rule, to show that the rule parameters are robust to most of the output gap measures and the specifications considered, i.e. the inflation coefficient is above unity and the output gap coefficient is positive. The estimated rule is shown to track the actual policy performance during the EMU period remarkably well. In addition, the estimated rule is used as an indicator of macroeconomic convergence in the union and it is demonstrated that the optimal EMU rate has not been in accordance with domestic conditions in certain countries.

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1 Introduction

Following a policy rule mechanically when operating monetary policy is neither realistic nor practical; it would be deceptive and simplistic to believe that a simple policy rule can be implemented in the daily conduct of policy by the central bank. A first reason is that such a rule would be incapable of processing all the information that is indicative of macroeconomic developments and may help to interpret the current economic situation. Furthermore, given that different sources of shocks call for different policy responses, a simple rule is too restrictive to be used as the sole reliable indicator. Moreover, there are practical difficulties in the actual implementation of such rules, since some of the variables entering the rule are not directly observable, and are likely to be prone to real time mismeasurement.

Nevertheless, monetary policy rules have received a great deal of attention in recent macroeconomic research. Quoting from the European Central Bank (from now on abbreviated as ECB) Monthly Bulletin (October 2001, p.38): "*The emphasis on rule-guided monetary policy... is generally welcome [because] it provides a salutary antidote to the perennial risks of a discretionary, ad-hoc approach to policy-making.*"

Speaking of the virtues ascribed to the simple rules, it should be emphasised that they are easily verified ex-post by the private sector, and they simplify the communication of policy orientations to the general public. And as the ECB acknowledges, "*... an understanding of the central's banks actions is important for its credibility and, therefore, its effectiveness in achieving its objectives*"(Monthly Bulletin October 2001, p.38). This last feature of the simple monetary policy rules offered me the motivation to explore the properties of the Taylor rule.

Thus, this paper focuses on a simple feedback rule for the Euro-Area. Based on the relevant academic literature and the ECB publications, I specify the theoretical relationship between the short-run interest rate and the macroeconomic conditions, and then, by using Euro-Area aggregate data, I estimate its parameters. My main interest is the robustness properties of the rule and, for this purpose, I estimate it for various output gap measures and for two price indices. Additionally, making use of the estimated rule, I investigate the convergence in the macroeconomic conditions in the Euro-Area by checking the optimality of the implied EMU target rate for the member countries. To be more specific, in section 2, I briefly review the literature on interest rate rules, and in section 3, I give information on the method and the data used for the estimation. More interestingly, in section 4, I present the results of the robustness analysis, and, in section 5, I select one specification and check whether it fits the data. In section 6, I examine the optimality of the rule-indicated EMU target for the member countries with the intention to comment on convergence. Finally, section 8 offers concluding remarks.

2 The benchmark monetary policy rule

The behavior of an independent central bank is typically captured by a pair of equations. The first is the economic structural equation, which describes how a set of endogenous variables (including, for example, inflation and output) is related to a set of variables outside the control of the central bank, to current and past values of the interest rate set by the central bank and to a random shock. The second equation is the reaction function, which describes how the central bank responds to the macroeconomic conditions of the country. In the EMU framework, the national banks' reaction functions have been replaced by a single reaction function, which responds to the EMU state of economy. As recognized by the ECB, *"...the central bank's operational framework, by and large, makes it more natural to think of the interest rate as the policy instrument rather than the monetary base"* (Monthly Bulletin, October 2001, p.38).

In this section, I describe the developments concerning the monetary policy rule that I make use of in the following sections. This particular benchmark is the so-called Taylor rule; a simple rule that gives the optimal interest rate as a function of the conditions of the economy, and that *"has become rather popular both in academic literature and among professional central bank watchers in recent years"*, according to the ECB Monthly Bulletin (October 2001, p.40).

To be more specific, Taylor (1993) proposed a simple monetary rule which was found to track actual monetary policy in the United States surprisingly well in his empirical testing on data from the late 1980s until 1992. The original formulation was

$$i_t^* = \pi_t + \theta_1(\pi_t - \pi_t^*) + \theta_2(y_t - y_t^*) + \overline{r_t}, \tag{1}$$

where θ_1, θ_2 are parameters, i_t, π_t, and y_t denote the federal funds rate, inflation and output respectively, * denotes target values and $\overline{r_t}$ is the equilibrium long-run real rate. In words, monetary authorities adjust the short-term interest rate in response to inflation deviations from its target level, and to the size of the output gap. Equation (1) can be rewritten as:

$$\begin{aligned} i_t^* &= \overline{i_t} - \beta\pi_t^* + \beta\pi_t + \gamma(y_t - y_t^*), \\ i_t^* &= \overline{i_t} + \beta(\pi_t - \pi_t^*) + \gamma(y_t - y_t^*), \qquad (2) \\ i_t^* &= \alpha + \beta\pi_t + \gamma x_t, \qquad (3) \end{aligned}$$

where $x_t = y_t - y_t^*$ is the output gap, $\overline{i_t} = \overline{r_t} + \pi_t^*$ is the equilibrium nominal rate, $\beta = \theta_1 + 1, \gamma = \theta_2$ and the constant term is defined as $\alpha \equiv \overline{i_t} - \beta\pi_t^*$.[1] According to

[1] Although π_t^* and $\overline{i_t}$ cannot be identified separately, using the estimates of α and β it is possible to recover an estimate of the central bank's target inflation rate, π_t^*, for a given value of $\overline{i_t}$. See section 5.

Taylor, $\theta_1 = \theta_2 = 0.5$, $\pi_t^* = 2$, $\overline{r_t} = 2$, and he specified the rule as follows:

$$i_t^* = \pi_t + 0.5(\pi_t - 2) + 0.5x_t + 2, \quad (4)$$
$$i_t^* = 1 + 1.5\pi_t + 0.5x_t. \quad (5)$$

While it is commonly acknowledged that, given the uncertainty of macroeconomic developments, neither the United States Federal Reserve nor the European Central Bank could consider giving up discretionary authority over monetary policy, the Taylor rule has received a great deal of attention due to its good tracking of policy moves. However, there are numerous uncertain issues concerning the specification of the rule. In what follows I refer to a number of surveys that have used some type of Taylor rule.

A first issue is whether the interest rate target should respond solely to actual and observed values, as it does in the Taylor (1993) rule, or to a measure of expected future inflation (the so-called forward-looking response). Clarida & Gertler (1996) used a forward-looking version of the simple Taylor (1993) rule to argue that monetary policy in the German economy, contrary to the conventional view according to which the Bundesbank was targeting a money aggregate, is well described by a Taylor rule rather than well modeled as a monetary targeting experience. Clarida et al. (1998) have investigated monetary policy-making in Europe by estimating various reaction functions, where the central bank adjusts the nominal short-term interest rate to respond to the gaps of expected inflation and output from their respective targets. Again they applied a forward-looking version of the Taylor rule, and offered evidence to support that their baseline forward-looking specification works quite well against various alternatives, including the backward-looking one.

In a more recent work, Clarida et al. (2000) have again estimated a forward-looking monetary policy reaction function for postwar United States. They have pointed out that their specification nests the Taylor rule as a special case, and they observed that, when estimating the coefficients of the rule, results may be misleading in the case where neither lagged inflation nor any linear combination of lagged inflation and output gap are sufficient statistics for forecasting inflation. The reason for this is that, in addition to the size of the policy response, estimated coefficients capture the ability of each variable to forecast the state of the economy. Nonetheless, they have found that during the 1987- 1992 period analyzed by Taylor, their target rate tracks the actual rate about as well as the simple Taylor (1993) rule does. Moreover, they have observed that their main conclusions can be obtained from a backward-looking specification as well.

In the same context, Dornbusch, Favero & Giavazzi (1998a) have also worked on the monetary mechanism in Europe. They have estimated monetary policy reaction functions, assuming that the central bank adjusts the nominal short-term interest rate to respond to the state of the economy, which, according to these authors, is described by the deviations of expected inflation, output and nominal exchange rate from their target levels. Thus, they extend the closed-economy specification adopted by the previously mentioned authors to an open economy, and they comment that their results could have been produced from estimating either a forward-looking model or a genuine Taylor rule; the reason for this being that they focus on equilibrium parameters, and in equilibrium expectational errors are not relevant.

Regarding the question of whether an interest rate response to the forecast of inflation would work better than an interest rate response to the actual inflation rate, Taylor (1999) has argued that forward-looking rules are based on current and lagged data, since forecasts are based on them. As a result, in his opinion, inflation forecast rules are not more forward-looking than rules that explicitly react to current and/or lagged variables.

To continue, a second uncertain issue concerning the interest rate setting is whether the short-term interest rate should respond to other variables that describe the state of the economy, in addition to inflation and to the output gap. Goodfriend (1991) has argued that the central bank cares about smoothing changes in the interest rate, for fear of disrupting capital markets, or of losing credibility from sudden and large policy reversals, or in order to support policy changes, while Rudebusch (1995) has provided evidence on serial correlation of interest rate changes. In this perspective, Clarida et al. (1998), Dornbusch, Favero & Giavazzi (1998a) have included an adjustment mechanism in the reaction functions they have estimated. Thus, assuming that the central bank is concerned about smoothing changes in the interest rate, the actual rate adjusts accordingly:

$$i_t = (1-\rho)i_t^* + \rho i_{t-1} + \upsilon_t, \tag{6}$$

$$i_t = (1-\rho)\alpha + (1-\rho)\beta\pi_t + (1-\rho)\gamma x_t + \rho i_{t-1} + \upsilon_t, \tag{7}$$

where $\rho \in [0,1]$ captures the degree of interest rate smoothing, and υ_t is an *i.i.d.* disturbance representing exogenous shocks to the short rate, arising, for instance, in the market for reserves or in the exchange rate risk. Equation (7) combines the target equation (3) with the adjustment mechanism (6).

Speaking of additional variables that may influence rate setting, Dornbusch, Favero & Giavazzi (1998a) have considered deviations of the nominal exchange rate, while Clarida et al. (1998) have considered a number of alternatives including monetary aggregates and foreign countries' short-term interest rates. To include such a variable, say z_t, the target rate relation can be modified accordingly (Clarida et al. (1998)):

$$i_t^* = \alpha + \beta\pi_t + \gamma x_t + \eta(z_t - z^*). \tag{8}$$

A third uncertain issue is the size of the parameters; that is whether the interest rate should respond to actual inflation or real output by a larger or smaller amount than the benchmark rule. The central bank is assumed to choose the short-term interest rate in an environment with nominal rigidities where monetary policy affects real activity in the short-run; by varying the nominal rate, the central bank effectively varies the real rate. Clarida et al. (1998) have emphasized the importance of the inflation rate coefficient size, since it determines the stabilizing properties of the rule. If $\beta < 1$, the target rate adjusts to accommodate changes in inflation; this is because, even though the central bank raises the nominal rate in response to the rise in inflation, the increase is not sufficient to keep the real rate from declining. In the opposite case, where $\beta > 1$, the target rate adjusts to stabilize inflation, and if in addition $\gamma > 0$, output stabilizes as well.

In the same spirit, Smets (1998) has emphasized the crucial role of the output gap in the attempt to stabilize inflation. He notes that even if the central bank cares solely about inflation stabilization, it has to respond significantly to the output gap. Gerlach & Smets (1999) assert the central role of the output gap in the monetary transmission mechanism, particularly in a relatively closed economy such as the EMU area. They justify its importance to the practical conduct of monetary policy (even if the primary objective is to maintain price stability) by arguing that short-term interest rates influence aggregate demand and the output gap, which in turn affect inflation through a Phillips-curve relationship.

Indeed, it shall be pointed out that there is still great uncertainty about measuring potential GDP. Orphanides (2000) has argued that output gap mismeasurement problems, due to lack of information in real time, impose significant impediments to a successful stabilization policy. He argues that the work of the authors mentioned earlier in this section (and of many others)[2] on how reaction functions related to equation (3) describe the central bank's behavior is based on absence of informational problems. He considers this as an 'unrealistic informational assumption', and he believes that in order to construct a realistic and trustworthy policy alternative, the noise in the measurement of inflation and output gap should be taken into account. Smets (1998), focusing on the measurement error in the output gap, has proved that such error can partially explain why central banks respond relatively more to inflation than to the output gap, compared with a situation in which the output gap is known.

Despite the reduced efficiency caused by the poor estimation of the variables, the rule remains inherently stable. In this context, Taylor (1999) has simulated different interest rate rules in a seven-country large open economy model, and has found that simple policy rules, with the inflation coefficient above the unity critical threshold, are efficient and robust, even more robust than complex ones across a variety of models. Moreover, he argues that the basic results about simple policy rules designed for the United States seem to apply broadly to many countries. Thus, he suggests that the simple benchmark rule proposed in 1993 shall be used as a guideline for the ECB.

[2] To mention some, Ball (1997), Rotemberg & Woodford (1998) and Svensson (1997).

3 An interest rate rule for the Euro-Area

3.1 The unique nature of the exercise

Bearing in mind the numerous surveys supporting the good performance of the Taylor rule, in this section I use Euro-Area aggregate data to estimate such a rule for the EMU and check its robustness to various output gap measurement methods, and to price indices.

The Maastricht Treaty, which governs the ECB, assigns to the bank the mandate or the 'primary objective' to maintain price stability. Therefore, one can expect the inflation coefficient to be above the threshold of unity so as to ensure inflation stabilization. In addition, the ECB is encouraged, 'without prejudice to its primary objective', to support the general economic policies in the Community, which include a long list of desirables (e.g., a high level of employment). As a result, it is expected that the output gap coefficient will be positive, although not particularly high.[3]

With respect to the inclusion of the exchange rate, the Treaty states that 'the Council of Ministers may formulate general orientations for exchange rate policy' and adds that these orientations 'shall be without prejudice to the primary objective of the ECB'. However, devaluation could be expected to disturb ECB's principal target of price stability and therefore it may be a factor that determines rate setting. Thus, although nominal exchange rate deviation has no reason to appear among the regressors, its inclusion in the instrument list is plausible. As for the role of various monetary aggregates, the ECB has explained that it reaches its primary objective by means of a "two-pillar" strategy: the first pillar consists of a reference value for the growth of the broad money supply (M3) and the second of a collection of forecasts and indicators of inflation. Thus, the growth of M3 is a candidate variable to be included in the interest rate relation.

My attempt to estimate an interest rate feedback rule for the Euro-Area is, however, subject to pitfalls. In the first place, the ECB is a newly founded institution that began full operations in January 1999. Moreover, the Euro Area is itself a newly formed entity; thus, the Euro-Area published data is synthetic and calculated on the basis of weighted national data. However, it seems more appropriate to conduct the analysis using aggregate (rather than disaggregated) data because the ECB is expected to focus on EMU-wide developments; by doing so it avoids pressure to pay attention to country-specific conditions. An often-heard criticism of the empirical research on the EMU is that all conclusions and implications are based on historical pre-EMU data, and that a regime shift of the magnitude of a new monetary union can possibly invalidate any results obtained from past data. Much as I understand

[3] One may argue that unless there is an explicit output smoothing objective, the information embodied in the current output gap is implicitly taken into account by the inflation forecast term. However, in a model estimated for an aggregate of five EU countries, Peersman& Smets (1998) have shown that even if the central bank focuses solely on inflation and attaches zero importance on output, the Taylor rule will include a strong response to the output gap.

that structures in member countries have changed significantly, it seems that the adjustments have not been so abrupt as to make historical data irrelevant.[4] Besides, as Gerlach &Smets(1999) posit, the EMU policy environment is not a completely new environment, as it was preceded by a gradual process of monetary convergence.

Similar exercises in the literature Clausen & Hayo (2002) estimate an interest rate rule with current inflation rate. They use aggregate data constructed by weighting national data from Germany, France and Italy for the period 1979:1-1996:4 (the weights correspond to the shares of national GDP in the aggregate). Another comparable exercise has been presented by Mihov (2001). He estimates a forward-looking interest rate rule with pooled data from Germany, France and Italy for the period 1990:3-1998:4, and uses the coefficients of this regression as a proxy for the Euro-Area reaction function. Gerlach & Schnabel (2000) regress the actual EMU-11 interest rate on the EMU output gap and the current inflation rate, accounting for exchange rate volatility in the EMS. They repeat the exercise for a forward-looking specification. Their sample period is 1990:1-1998:4 and the data is constructed by aggregating weighted data from the 11 European countries (using OECD weights).

None of the above surveys has considered the robustness of the rule to the output gap, an unobservable variable that is subject to great uncertainty and can be significantly affected by the method employed for its estimation. Moreover, none of the above makes use of the officially published Euro-Area data; instead they use self-constructed aggregate measures. Some of them work with only 3 out of the 11 member countries. Furthermore, their sample period stops before the start of the EMU.

Special reference will be made to the work of Gerdesmeier & Roffia (2003).[5] They evaluate whether alternative specifications of the original Taylor rule, based on the inclusion of additional variables or the use of different measures of the output gap and the inflation term, can better track the interest rate setting in the Euro-Area. Their data, which cover the years 1985 to 2002, are aggregated, and weighted national data of the EMU member countries for the period before January 1995 (or 1999 for some series), and thereafter official Euro-Area statistics are used.

3.2 Alternative output gap measures

The output gap is the difference between the actual and the potential output of the economy: it measures the deviation of output from its equilibrium level, and as such offers information on the state of the economy. Nevertheless, neither the potential output nor the output gap can be observed directly, but instead they need to be estimated. The methods mentioned in the literature can be classified into three broad

[4] Mihov (2001) provides statistical evidence against the presence of a structural break in January 1999.

[5] Their work came out after the submission of the first version of the paper in December 2002.

categories: statistical methods, structural approaches and the production function method (Dimitz (2001)).

Following the literature, I construct for the Euro-Area a number of output gap measures that have been suggested for other economies. To be more specific, Clarida et al. (2000) use the deviation of log GDP from a fitted quadratic function of time, and alternatively the deviation of the unemployment rate from a similar time trend-with the sign of the series alternated. Clarida et al.(1998) detrend the log of industrial production using a quadratic trend. Similarly, Dornbusch, Favero & Giavazzi (1998a) consider a quadratic trend of industrial production as a proxy for the target output. In addition to these methods, I also construct an output gap series based on the univariate Hodrick-Prescott filter (from now on abbreviated as HP).[6] Due to the non-availability of GDP data at a monthly frequency, I (like the above mentioned authors) construct my output gap measures using data on industrial production and unemployment.

The series named G_QUADR is the deviation (multiplied by 100) of the natural logarithm of the industrial production from a quadratic function of time. The series named G_UNEMPL is the deviation of the unemployment rate from a quadratic function of time with the sign switched around. Similarly, the series named G_HP14 and G_HP129 are the deviation (multiplied by 100) of the natural logarithm of the industrial production from its HP filter with the smoothing parameter λ equal to 14400 and 129600 respectively. The fifth output gap measure, G_OECD, is the one published by the OECD based on the production function approach.[7] Thus, I consider all the methods suggested by the literature on interest rate rules, plus the

[6] Concerning the HP filter, potential output is determined as the output level that simultaneously minimizes a weighted average of the gap between actual and potential output and the rate of change of the output trend. The only requirement for its calculation is output data, which makes the method simple. However, it has some disadvantages. One of these is the need to fix the so-called smoothing parameter. Another one is the so-called end-of-sample problem that arises because at the end and at the beginning of the sample period the penalty for letting potential output follow the trend of the data will be small, since the filter does not take the subsequent reversion of the trend into account and it simply extends the latest trend to the future. Thus, the otherwise symmetric HP filter becomes asymmetric towards the end of the series with a disproportionate emphasis placed on the last few observations. A way of dealing with this problem is to add projections of the series.

The smoothing parameter λ determines the smoothness of the trend estimates. A low value produces a filter that follows actual growth closely and is therefore very volatile, while a higher value produces smoother trend estimates that follow actual output less closely. In more detail, for monthly data, a filter with $\lambda = 14400$ filters cycles lasting more than 20 years, or, in other words, it incorporates them into the trend, while cycles of 15-16 years are considered cyclical. In a filter with $\lambda = 129600$, cycles that last about 20 years are considered cyclical. The choice of λ values is based on Canova (1997), McMorrow& Roeger (2001) and Uhlig& Ravn (2001). For quarterly data, Hodrick & Prescott (1997) suggest $\lambda = 1600$.

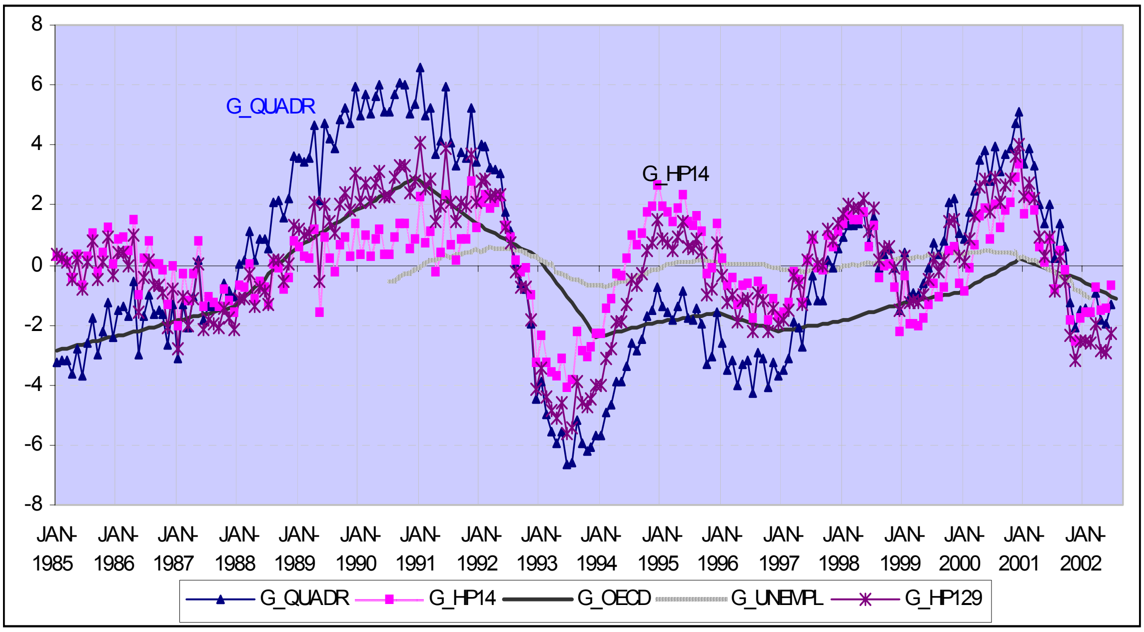
[7] Here the potential output is calculated using a production function relationship and estimates of the factor inputs available in the economy; for more information, see Giorno et al. (1995). The output gap equals the difference of actual GDP from potential GDP as a percentage of potential GDP (OECD Economic Outlook).

HP filter, which is said to produce similar results with a number of other statistical and semi-structural methods, plus a production function method.

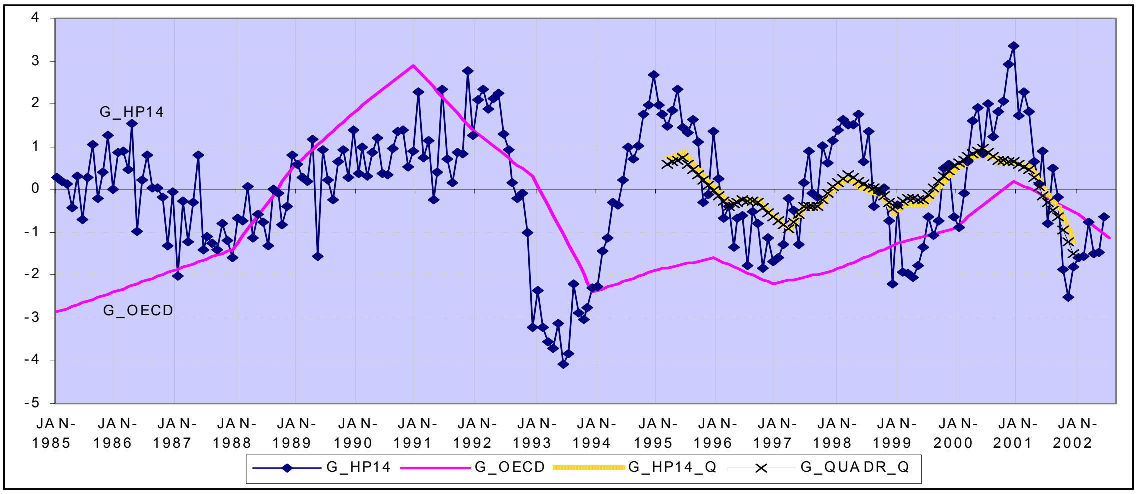
Nevertheless, the ECB ought to focus on overall GDP and not just on industrial production that is more volatile than GDP. Thus, it may be instructive to compare the results with estimations produced with output gap measures built on GDP data. For this purpose, I have created two gap measures based on quarterly GDP data, i.e. the deviation of log GDP from a fitted quadratic function of time (named G_QUADR_Q) and from a HP filter with λ=1600 (named G_HP14_Q). These measures are then converted to monthly frequency using an interpolation method that assigns each value in the low frequency series to the last high frequency observation associated with the low frequency period, and places all intermediate points on straight lines connecting these points.

The output gap series are plotted in figure 1.[8] The spectral analysis has not given rise to concerns, although there are differences in the autocorrelations and partial autocorrelations; the picture is similar for the measures based on the industrial production data (G_QUADR, G_HP14 and G_HP129), but differs for G_UNEMPL and for G_OECD.

Figure 1: Output gap series (from monthly and quarterly data)



[8]Gerdesmeier & Roffia (2003) derive the potential output by fitting a trend (both in linear and quadratic terms) to the data (both industrial production and real GDP) and by employing the HP filter- with λ=14400 for monthly data and λ=1600 for quarterly data.



To explore further the robustness of the rule, I also consider an alternative measure of inflation, namely what the literature calls 'core inflation'. This measure excludes the relatively more volatile components of the Index of Consumer Prices.

3.3 Data and method used for estimation

3.3.1 Estimation method

An attempt to estimate an interest rate rule of the form $i_t = c_1 + c_2\pi_{t+n} + c_3x_t + \varepsilon_t$ (for $n \geq 0$) resulted in an *adjusted* R^2 below 20% and in autocorrelation problems. To achieve a better specification, I considered including variables describing exchange rate and money supply. This resulted in a significant rise in the *adjusted* R^2, but the residuals were still autocorrelated. Accounting for interest rate smoothing produces estimations with high *adjusted* R^2 and uncorrelated residuals. Therefore, the starting equation of my analysis is

$$i_t = c_1 + c_2\pi_{t+n} + c_3x_t + \rho i_{t-1} + \varepsilon_t, \;\; for\ n \geq 0. \tag{9}$$

Putting aside the issue of whether the rule ought to include current or future inflation, and of whether other factors affect rate setting, it is true that the output gap, a right-hand side variable, is measured with error and, to make matters worse, the interest rate is an important determinant of both inflation and output. All these may possibly imply $cov(\pi_t, \varepsilon_t) \neq 0$ and/or $cov(x_t, \varepsilon_t) \neq 0$. This violation is known to result in biased and inconsistent Ordinary Least Squares estimators. In such a case, the standard approach is to implement an instrumental variables regression. The method applied here is the Two Stage Least Squares (TSLS from now on), a special case of the instrumental variables regression. All estimations are performed with EViews.

The instrument set includes lagged values (in most cases from the first to the sixth, the ninth and the twelfth lag and in no case more than 24 lags) of the output gap, the inflation rate, the interest rate, the United States core inflation rate, the monthly difference of the (logarithm) euro real effective exchange rate and the (percentage) deviation of (the natural logarithm of) the money supply from its HP trend (with $\lambda = 14400$).[9]

In the forward-looking specifications, I use actual values, and not expected or forecasted ones. Apart from lacking reliable data, it is controversial to choose among forecasts, in the absence of official and commonly accepted forecasts. Besides, this is a common practice in the literature where official projections do not exist. However, it should be clear that in this way I assume perfect foresight.

Like most of the authors involved in the literature, I base my analysis on the fundamental assumption that within short samples short-term interest rates and inflation are stationary. Nevertheless, I have applied a number of unit root tests, to find that for the full sample, non-stationarity cannot be rejected for the inflation and the interest rate series, while for the post-1999 period there is strong evidence of stationarity.

3.3.2 The data

My data are monthly time series for the Euro-Area and are obtained from the OECD Statistical Compendium unless otherwise indicated.[10] I use the Harmonized Index of Consumer Prices for all items (HICP) to measure inflation as the annual percentage change from the previous period level value: $\pi_t = 100(HICP_t/HICP_{t-12} - 1)$. The inflation rate series covers the period 1991:1 to 2002:07. To measure 'core inflation', I use HICP that excludes food, alcohol, beverage, tobacco and energy components. The inflation is again measured in annual percentage changes and the data spans the period 1991:01 to 2002:02.[11] As a variable to extract information on monetary policy, I use the Interbank deposit bid rates until December 1998 and from January 1999 the euro overnight index average (EONIA) as published by the European Central Bank. This series covers the period 1994:1 to 2002:07.

As explained, to measure the output gap, I have used monthly data on seasonally adjusted industrial production; this is an index series that equals 1 in 1995 and covers the period 1985:01 to 2002:6. As for the gap built on unemployment data, I have used the standardized and seasonally adjusted unemployment rate in monthly frequency for the period 1990:7 to 2002:2. As for the output gap series published by the OECD, given that the OECD's estimates are annual, I have converted them to monthly

[9] The choice of the instrument list basically follows Clarida et al. (1998), with some modifications to account for the specific features of the economy in question.

[10] Luxembourg is included in all the Euro-Area series, but not in the G_OECD output gap series. This is not problematic given its small size, and for this reason the country is excluded from the analysis that follows.

[11] Both HICP are indices which take the value 1 in 1996, and are not seasonally adjusted. Mixing seasonally adjusted data with unadjusted data has not created any problems. However, it may be instructive to add seasonal dummies.

frequency using a linear interpolation method. This series begins in 1985:01 and finishes in 2002:7, utilizing OECD projections for the last seven months. To estimate the potential output I have also used quarterly GDP data (seasonally adjusted, in constant 1995 prices and expressed in billion euro- that covers the period 1995:1-2001:4).

Regarding the instruments, for the monetary aggregate I use the total M3 level measured at the end of each month, which is obtained from the ECB Monthly Bulletin for the months after 1998:1. The series starts in 1990:1 and finishes in 2002:7, and is not seasonally adjusted. As for the exchange rate, I use the real effective exchange rate (starting in 1990:1 and ending in 2002:7) as made available in the ECB Monthly Bulletin.[12] To measure US 'core inflation', I use an HICP that excludes food, alcohol, beverage, tobacco and energy components. The inflation rate is again measured in annual percentage changes and covers the period 1991:01 to 2002:02.

Given the various lengths of the series involved, the past values of the series used as instruments and the future values of inflation needed in the forward-looking specifications, in most of the estimations the sample period extends from 1995:1 to 2002:3, although it is shorter when core inflation and output gaps built on GDP enter the estimations.

4 Robustness Analysis

Three forms of uncertainty relevant to monetary policy can be identified: uncertainty about the state of the economy, about the structure and the functioning of the economy and about the strategic interaction between central banks and private agents. All of these may be increased by the regime shift associated with the formation of the EMU, which makes the ECB's job uniquely challenging. In the presence of important data and model uncertainty, it is highly desirable to ensure the "robustness" of any rule that may provide information either to the policy-makers or to the private agents. Thus, in this section I explore the robustness of the Taylor rule described earlier. This exercise is constructive, since, given that the ECB is a new institution, it needs to be predictable so as to prevent monetary policy itself from becoming a source of uncertainty.

I estimate various specifications for various output gap measures, and then compare the size of the estimated coefficients across a number of dimensions.[13] In this way, I may conclude whether the inflation coefficient exceeds unity or not, and whether the output gap coefficient is positive or negative. This comparison is made in terms

[12] Calculated as period averages using the CPI, it takes the value 100 in the first quarter of 1999. It refers to trade with the following countries: United States, Japan, UK, Sweden, Denmark, Norway, Canada, Australia, Hong Kong, Korea, Singapore.

[13] Gerdesmeier & Roffia (2003) check the robustness of the rule to various gap measures by estimating one specification for various gap measures. This is their baseline specification, which is a current version of the rule.

of the target interest rate equation (equation (3)).

In other words, as explained in section 3.3.1, the starting equation of my estimations is equation (9). The parameters of the implied target equation are derived from the estimated one by dividing all the coefficients by one minus the coefficient of the lagged interest rate (see equation (7)), i.e.:

$$\begin{aligned} i_t &= c_1 + c_2\pi_{t+n} + c_3 x_t + \rho i_{t-1} + \varepsilon_t \\ i_t^* &= \frac{c_1}{1-\rho} + \frac{c_2}{1-\rho}\pi_{t+n} + \frac{c_3}{1-\rho}x_t \\ i_t^* &= \alpha + \beta\pi_{t+n} + \gamma x_t, \end{aligned}$$

where β is what I call the inflation coefficient, and γ the output gap coefficient. As in the discussion following equation (3), $\alpha \equiv \overline{i_t} - \beta\pi_t^*$ from which the target inflation is derived, i.e. $\pi_t^* = \frac{\overline{i_t}-\alpha}{\beta}$. The interest rate series (1994:1-2002:7) is sufficiently long to use the sample average as an approximation of the long-run nominal rate $\overline{i_t}$, i.e. $\overline{i_t} = 4.389$. Splitting the period in two, into pre-EMU and EMU, the interest rate averages are $\overline{i_{PRE}} = 4.9$ and $\overline{i_{EMU}} = 3.66$. Analogously, the inflation sample averages for the same periods are: $\overline{\pi_t} = 2.07$, $\overline{\pi_{PRE}} = 2.09$ and $\overline{\pi_{EMU}} = 2.05$. Similarly for the core inflation: $\overline{\pi_t^c} = 1.92$, $\overline{\pi_{PRE}^c} = 2.19$ and $\overline{\pi_{EMU}^c} = 1.49$. In what follows, I compare the estimated target inflation π_t^* with the period's average; the closeness of π_t^* with $\overline{\pi_t}$ may be an indication of good fit of the equation to the data. Nevertheless, the sample period varies across equations, and differs, more or less, from the period averages reported here. Therefore, the comparison between π_t^* and $\overline{\pi_t}$ is just indicative.

4.1 Results for different specifications[14] [15]

Firstly, I estimate for various output gap measures the current version, i.e. $i_t = c_1 + c_2\pi_t + c_3 x_t + \rho i_{t-1} + \varepsilon_t$**.** All gap measures predict that $\gamma > 0$ with the exception of G_OECD, for which the coefficient is insignificant. As for β, G_OECD, and G_UNEMPL predict that it is around 1.5, whereas G_HP14 gives a coefficient below unity and G_QUADR, G_HP129 give an insignificant coefficient. The predicted inflation target from all equations is well above the sample average inflation. To check the stability of parameters, I apply the Chow Breakpoint Test for 1999:1 and 1998:6, and find that constancy cannot be rejected for G_OECD and G_UNEMPL, but it is rejected for G_QUADR, G_HP129 and G_HP14. There are no residual problems, and the *adjusted* R^2 takes a satisfactorily high value.

Secondly, I estimate the forward-looking version, i.e. $i_t = c_1 + c_2\pi_{t+n} + c_3 x_t + \rho i_{t-1} + \varepsilon_t$**.** After trying various expectation horizons, and comparing the

[14] In the appendix, I display the values of the estimated coefficients per specification and equation, as well as descriptive and other statistics.

[15] The effects of core inflation measure and the gap measures produced with quarterly data are explored only for selected specifications. The selection criteria are discussed in the following section.

adjusted R^2 across equations, as well as the t-statistic of c_2 and of the other coefficients, I set $n = 2$. This implies that the interest rate reacts to inflation two months ahead.

Except for G_QUAD, the coefficient of which is insignificant, all gap measures give $\beta > 1$. As for γ, G_QUADR, G_HP14, G_HP129 and G_UNEMPL predict that it is positive, whereas G_OECD produces a negative coefficient. There are no residual problems, and the *adjusted* R^2 is large.

Checking for the stability of parameters with the Chow Breakpoint Test for January 1999, except for G_QUADR and G_HP129, the constancy hypothesis cannot be rejected. However, for 1998:6, only G_OECD and G_UNEMPL predict stability. Moreover, note that, in order to capture the interest rate smoothing in the equation with G_OECD, apart from the first lag, the sixth one was included as well. Regarding the predicted inflation target, it is again above the period's average.

Concerning the output gap measures interpolated from quarterly GDP data, both predict a positive output gap coefficient, but neither gives a significant inflation coefficient. In addition, for both measures parameter stability is easily rejected.

As for the alternative inflation measure, the output gap measures predict that $\beta >$ 1- with the exception of G_HP14_Q-, and $\gamma > 0$ - with the exception of G_QUADR, G_OECD and G_UNEMPL where the estimator is insignificant. And as previously, the hypothesis of stable parameters checked in 1999:1 can be rejected- only for G_HP14_Q it cannot. Regarding the predicted inflation target, this time for all equations it is very close to the period's average. Not least, it is worth pointing out that, when the interest rate is regressed on core inflation, the forward-looking horizon becomes larger; it equals six months, with the exception of G_HP14_Q for which $n = 1$.

Thirdly, I consider the inclusion of a dummy variable to account for the start of the EMU. The dummy equals 0 for the pre-EMU period and 1 for the EMU period.

Version A: $i_t = c_1 + c_2\pi_{t+2} + c_3 x_t + \rho i_{t-1} + c_4 dummy + \varepsilon_t$

All gap measures predict significantly that $\gamma > 0$- except for G_OECD whose coefficient is insignificant- and $\beta > 1$. There are no residual problems, and the value of *adjusted* R^2 is satisfactorily large. Regarding the predicted inflation target, the majority of the gap measures predicts that the pre-EMU period inflation target is lower than that of the EMU period, although the relevant period averages suggest the opposite.[16]

[16] This is because in every case $\alpha_{EMU} < \alpha_{PRE}$. (Remember that $\pi_t^* = \frac{\overline{i_t} - \alpha}{\beta}$.) Besides, $\overline{\pi_{PRE}}$ and $\overline{\pi_{EMU}}$ differ slightly. In particular, for the months prior to January 1999, G_QUADR, G_HP14 and G_hp129 produce values very close to $\overline{\pi_{PRE}}$, while G_UNEMPL and G_OECD values above it. As for the EMU period: all gap measures predict an inflation target value close to the period average (except for G_UNEMPL whose target value exceeds the average by almost a unit).

Version B: $i_t = c_1 + c_2\pi_{t+2} + c_3 x_t + c_4 dummy + c_5 dummy * \pi_{t+2} + c_6 dummy * x_t + \rho i_{t-1} + \varepsilon_t$

For every one of the gap measures *dummy* and $dummy * x_t$ turn out to be insignificant.

Version C: $i_t = c_1 + c_2\pi_{t+2} + c_3 dummy * \pi_{t+2} + c_4 x_t + \rho i_{t-1} + \varepsilon_t$

The dummy is significant for all gap measures, except for G_OECD. G_QUADR and G_HP14 predicts that $\gamma > 0$, $\beta > 1$ for dates before 1999:1 and $\beta < 1$ for the months after. G_UNEMPL, G_OECD, and G_HP129 predict $\beta > 1$ for the period before and after January 1999, and (apart from the equation of G_OECD where the coefficient is insignificant) $\gamma > 0$. There are no residual problems, and the *adjusted* R^2 is satisfactorily large. Regarding the predicted inflation target, as in the previous specification, it happens that the pre-EMU predicted inflation target is lower than the EMU one.[17]

Concerning the output gap measures interpolated from quarterly GDP data, they both predict a positive output gap coefficient and in both equations the dummy is significant. However, although both give an inflation coefficient above unity for the period before January 1999, for the EMU period G_HP14_Q predicts that $\beta < 1$ and G_QUADR_Q that $\beta > 1$.

As for the alternative inflation measure, note first that with the exception of G_UNEMPL the dummy is insignificant. The output gap measures predict that $\beta > 1$ and $\gamma > 0$- with the exception of G_OECD and G_UNEMPL where the estimator is insignificant. As for the expectational horizon, $n = 2$ only for G_HP14 and G_HP129, whereas for G_OECD $n = 3$ and for the rest $n = 6$. Concerning the predicted inflation, there is a tendency for the various gap measures (the ones built on quarterly data included) to produce inflation targets close to the average. For G_UNEMPL, where the dummy is significant, the EMU inflation target is lower than the pre- EMU.

The results concerning the coefficients' size are summarized in table 1, where in addition I report the results of a Wald test on whether the β and γ take simultaneously the values originally suggested by Taylor (see equation (5)) .

[17]This is because in every case $\beta_{EMU} < \beta_{PRE}$. (Remeber that $\pi_t^* = \frac{\overline{i_t} - \alpha}{\beta}$.) Besides, $\overline{\pi_{PRE}}$ and $\overline{\pi_{EMU}}$ differ slightly. In particular, for the preEMU period it happens for various gap measures (even the ones built on quarterly data) to produce inflation targets close or above the period average. For the EMU period, there is a tendency for the gap measures (even the ones built on quarterly data) to produce inflation targets close or slightly above the period average, with G_UNEMPL and G_QUADR_Q giving the largest upward deviations.

Table 1a: Estimated coefficients for various gap measures (all items HICP)

	current specification			forward-looking specification									
							dummy			dummy multiplied			
				(simple)			as constant			with π_{t+2}			
	β	γ	TR	β	γ	TR	β	γ	TR	β		γ	TR
										pre-EMU	EMU		
G_QUADR	-	>0	✓	-	>0	✓	>1	>0	×	>1	<1	>0	××
G_HP14	<1	>0	✓	>1	>0	✓	>1	>0	✓	>1	<1	>0	✓×
G_HP129	-	>0	✓	>1	>0	✓	>1	>0	✓	>1	<1	>0	××
G_OECD	>1	-	×	>1	<0	×	>1	-	✓	>1		-	✓✓
G_UNEMPL	>1	>0	✓	>1	>0	✓	>1	>0	✓	>1	>1	>0	✓✓
G_QUADR_Q				-	>0	×				>1	>1	>0	××
G_HP14_Q				-	>0	×				>1	<1	>0	××

Table 1b: Estimated coefficients for various gap measures (core inflation rate)

	forward-looking specification						
				dummy multiplied			
	(simple)			with π_{t+2}			
	β	γ	TR	β		γ	TR
				pre-EMU	EMU		
G_QUADR	-	-	×	>1		>0	××
G_HP14	>1	>0	×	>1		>0	✓✓
G_HP129	>1	>0	×	>1		>0	✓✓
G_OECD	>1	-	×	>1		-	✓×
G_UNEMPL	>1	-	✓	>1	>1	-	✓✓
G_QUADR_Q	>1	>0	✓	>1		>0	××
G_HP14_Q	-	>0	×	>1		>0	✓✓

Note: The current specification is $i_t = c_1 + c_2\pi_t + c_3x_t + \rho i_{t-1} + \varepsilon_t$. The simple forward-looking specification is $i_t = c_1 + c_2\pi_{t+2} + c_3x_t + \rho i_{t-1} + \varepsilon_t$.The forward-looking specification with the dummy as a constant is $i_t = c_1 + c_2\pi_{t+2} + c_3x_t + \rho i_{t-1} + c_4 dummy + \varepsilon_t$. The forward-looking with the dummy times π_{t+2} is $i_t = c_1 + c_2\pi_{t+2} + c_3 dummy * \pi_{t+2} + c_4x_t + \rho i_{t-1} + \varepsilon_t$. The dummy equals 0 for the pre-EMU era and 1 for the EMU period. Regarding notation: β is the inflation coefficient, γ the output gap coefficient and "-" indicates insignificance at the 5% level. As for the column with the heading "TR" it reports whether the hypothesis of $\beta = 1.5$ and $\gamma = 0.5$ can be rejected; "×"indicates rejection and "✓"the opposite.

Fourthly, a measure of the money supply has been added to the regressors of the estimated equation. As discussed in section 3.1, it may be that the interest rate reacts to the growth of the broad money supply (M3). To explore this possibility, I estimate the following equation: $i_t = c_1 + c_2\pi_{t+n} + c_3x_t + c_4z_t + \rho i_{t-1} + \varepsilon_t$ for $n \geq 0$ and $z_t = 100(\ln M3_t - \ln M3_{t-1})$ or $z_t = 100(\ln M3_t - \ln M3_{t-12})$. Accordingly, in the instrument list, the lags of the deviation of money supply from its HP trend are replaced by the lags of z_t. For both z_t definitions, and for all the gap measures considered, c_4 turns out to be negative. This is contrary to what one would expect, since higher money supply growth should provoke an interest rate increase in order to prevent inflation from rising. Due to this counterintuitive sign of the money growth coefficient, and to the fact that its addition does not result in a dramatically better fit nor does it change the predictions for β and γ, I have decided to continue without it.[18]

4.2 Overall results: across output gap measures and specifications[19]

The *adjusted* R^2, being an indication in favor of the estimated rule, varies from 94% to 97%. In addition, there are no serial autocorrelation problems with the residuals. Regarding the estimators, with a couple of exceptions, they have the expected sign and magnitude; as a rule, the output gap coefficient is significant and positive and the inflation coefficient is above unity, albeit only slightly.

G_HP14 and G_HP129 produce significant and very similar estimators in magnitude. G_QUADR, in spite of its being a comparable method, does not give a significant inflation estimator very often. G_UNEMPL, as a rule, produces the largest estimators; the output gap coefficient exceeds unity, and in many cases, it even exceeds 2. G_OECD is certainly a particular case: as a rule, the output gap coefficient is insignificant and when it becomes significant it is negative! Moreover, concerning the interest rate smoothing it is occasionally necessary to include the sixth lag of the interest rate in addition to the first. On a regular basis, G_OECD produces significant inflation coefficients whose values are among the highest. As for the inflation target, G_UNEMPL and G_OECD predict relatively higher values than the rest.

More interestingly, compared with the current version, the forward-looking produces larger inflation coefficients (that plainly exceed unity) and smaller output gap coefficient estimators (albeit positive), as well as a lower target inflation rate and an interest rate smoothing coefficient. Moving further, to compare the simple forward-looking version with the forward-looking version with a dummy as a constant, the inflation coefficient exceeds unity even more. As for the level of the target inflation rate from the first specification, for some gap measures it is closer to the EMU period target inflation rate and for others closer to the pre-EMU one, as these are predicted from the second specification. More importantly note that the majority of the gap measures predicts a lower inflation target for the pre-EMU era than for the EMU period, contradicting what the period averages suggest. [20] To complete the

[18] Gerdesmeier & Roffia (2003) report that money supply developments enter significantly as an additional variable in the rule, reducing the estimates of both β and γ; this may be due to the way they construct their money supply indicator.

[19] In these comparisons the gap measures from quartely GDP data are ignored because of their inferior fit to the data.

[20] However, the difference between the two periods is not very large. Putting aside a couple of

comparison across specifications, let me focus on the forward-looking version with the dummy multiplied with the inflation rate. Juxtaposed with the simple forward-looking version, it produces higher inflation rate coefficients when compared with the pre-EMU estimators and lower when compared with the EMU ones. Juxtaposed with the forward-looking version with a dummy as a constant, it produces higher pre-EMU inflation rate coefficients and alike EMU ones. In addition, the inflation target values are very similar for both periods across the two specifications. Note, however that, as previously, the pre-EMU target inflation rate is lower than the EMU target level- although the deviations are slight.

As for the output gap coefficient, it turns out that the current specification produces the highest estimators, followed by the simple forward-looking version and the dummy augmented forward-looking version. Lastly, as far as the interest rate smoothing coefficients are concerned, the current specification produces higher estimators compared to the simple forward-looking version, which produces higher estimators compared to the forward specification with the dummy as a constant, which in turn produces higher estimators when compared with the forward specification with the dummy multiplied with the inflation rate.

Regarding the alternative inflation measure, namely core inflation, it is instructive to make some comparisons. Firstly, comparing the results across gap measures, G_HP14 and G_HP129 produce similar estimators and target inflation levels and G_OECD behaves as described previously. G_UNEMPL still produces the highest inflation coefficient estimator, but the gap coefficient is insignificant in both specifications where the core inflation has been included. Secondly, between the two specifications that have been estimated with core inflation as a regressor, i.e. the simple forward-looking and the forward-looking with the dummy multiplied with the inflation rate, the simple one produces higher inflation coefficients (and higher interest rate smoothing coefficients), but lower (and more frequently insignificant) gap coefficients and target inflation levels. Thirdly, juxtaposed with the simple forward-looking specification of the broad HICP inflation rate, the simple version of the core inflation produces higher inflation rate coefficients, but lower (and more frequently insignificant) gap coefficients, target inflation levels and interest rate smoothing coefficients. Juxtaposed with the forward-looking specification of the broad HICP inflation rate with the dummy multiplied with the inflation rate, in the analogous version of the core inflation the dummy is insignificant in almost all equations. In addition, it seems that the equations with core inflation produce lower gap coefficients (and interest rate smoothing coefficients), inflation rate coefficients that lie between the pre-EMU and EMU broad HICP ones, and inflation target values that are relatively closer to the pre-EMU value as predicted by the broad HICP. However, there are too many exceptions to have a clear-cut idea.[21]

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exceptional values (namely the ones from G_OECD and G_UNEMPL), the two targets differ by less than half unit.

[21] Gerdesmeier & Roffia (2003) have found that using a HICP index that excludes food and energy

5 The preferred interest rate target rule

5.1 Specification Selection

To begin with, a choice between the current and the forward-looking specifications has to be made. To do so, the following equation is estimated:

$$i_t = c_1 + c_{2a}\pi_{t+2} + c_{2b}\pi_t + c_3 x_t + \rho i_{t-1} + \varepsilon_t.$$

It turns out that for G_OECD and G_UNEMPL the coefficient of expected inflation is significant, while the coefficient of current inflation is insignificant. For the rest of the gap measures, both coefficients are simultaneously insignificant. Even with different expectational horizons, i.e. $n = 3$ or 6, the results remain the same. In addition, the *adjusted* R^2 for each equation is compared; in all cases, current or forward-looking, it is close to 96%. Therefore, based on the previous arguments, it seems more appropriate to adopt a forward-looking specification.

Next, I compare the various forward-looking specifications. In the specification,

$$i_t = c_1 + c_2\pi_{t+2} + c_3 x_t + c_4 dummy + c_5 dummy * \pi_{t+2} + c_6 dummy * x_t + \rho i_{t-1} + \varepsilon_t,$$

the regressors *dummy* and $dummy * x_t$ are insignificant for all the gap measures. Therefore, the specification,

$$i_t = c_1 + c_2\pi_{t+2} + c_3 dummy * \pi_{t+2} + c_4 x_t + \rho i_{t-1} + \varepsilon_t, \tag{10}$$

is preferred to $i_t = c_1 + c_2\pi_{t+2} + c_3 x_t + \rho i_{t-1} + c_4 dummy + \varepsilon_t$.

To finish the specification selection, a choice ought to be made between equation (10) and $i_t = c_1 + c_2\pi_{t+2} + c_3 x_t + \rho i_{t-1} + \varepsilon_t$. Comparing the *adjusted* R^2 of both specifications for each equation, I find that for every gap measure (with the sole exception of G_QUADR_Q), the dummy-augmented specification produces higher *adjusted* R^2 and better residuals (even in terms of autocorrelation). Besides, a dummy augmented specification incorporates the rejection of the parameters' stability hypothesis observed for the vast majority of the specifications. Thus, equation (10) is maintained for the rest of the analysis.

As for selecting among the various gap measures, the *adjusted* R^2 among equations are compared to find that G_HP14 produces the higher value (with the G_HP129 producing the second value in order). This is a satisfying outcome given the results presented in the previous section, according to which G_HP14 has not produced any estimators out of the ordinary.

To conclude, equation (10) with x_t standing for G_HP14 prevails.

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delivers a higher β and a lower γ estimate. In general, concerning the sensitivity of the results to the various output gap measures, they argue that the estimates do not seem fully robust. However, their conclusion is based on a single specification, which, according to the specification selection procedure adopted in the present paper, is not superior to the others.

5.2 The preferred interest rate rule

Equation (10) has been estimated with TSLS, to produce:

$$i_t = \underset{(4.17)}{0.509} + \underset{(4.74)}{0.355\pi_{t+2}} - \underset{(-4.06)}{0.14 dummy * \pi_{t+2}} + \underset{(5.33)}{0.102 x_t} + \underset{(15.91)}{0.736 i_{t-1}} + \hat{\varepsilon}_t \tag{11}$$

The numbers in the parentheses are t-statistic values. In table 2, summary statistics are presented.

Table 2: Summary statistics for equation (11)

R-squared	0.96		test stat	prob
Adjusted R-squared	0.96	Breusch-Godfrey LM (H_0= no autocorrelation)		
S.E. of regression	0.19	2 lags	1.45	0.48
Sum squared resid	2.97	6 lags	6.9	0.32
Mean dependent var	4.2	12 lags	16.6	0.16
S.D. dependent var	1.01	ARCH Test (H_0= no ARCH)		
F-statistic	590	6 (2) lags	7.6(4.3)	0.2(0.1)
Prob(F-statistic)	0.00	Jarque-Bera (H_0= normality)	1.04	0.59
White Test (H_0= no heteroskedasticity)			13.1	0.43

As explained in the discussion opening the fourth section, the parameters of the implied target rule are derived from the estimated equation by dividing all the coefficients by one minus the coefficient of the lagged interest rate. It follows that the optimal target rule is:

$$\begin{aligned}
i_t^{*preEMU} &= \frac{0.50955}{1-0.73667} + \frac{0.355538}{1-0.73667}\pi_{t+2} + \frac{0.102437}{1-0.73667}x_t \Rightarrow \\
i_t^{*preEMU} &= 1.935 + 1.35\pi_{t+2} + 0.389x_t \Rightarrow \\
\alpha &= 1.9,\ \beta^{preEMU} = 1.35,\ \gamma = 0.4, && (12)\\
i_t^{*EMU} &= \frac{0.50955}{1-0.73667} + \frac{0.355538-0.14065}{1-0.73667}\pi_{t+2} + \frac{0.102437}{1-0.73667}x_t \Rightarrow && (13)\\
i_t^{*EMU} &= 1.935 + 0.81604\pi_{t+2} + 0.389x_t \Rightarrow && (14)\\
\alpha &= 1.9,\ \beta^{EMU} = 0.82,\ \gamma = 0.4, && (15)
\end{aligned}$$

where $\alpha \equiv \overline{i_t} - \beta\pi_t^*$ and $\pi_t^* = \frac{\overline{i_t} - \alpha}{\beta}$. The corresponding sample period's mean is used as an approximation of $\overline{i_t}$, and given the parameters' values in (12) and (15), it follows that $\pi_t^{*preEMU} = \frac{4.604791667-1.935}{1.35} = 1.9776$ and $\pi_t^{*EMU} = \frac{3.711794872-1.935}{0.81604} = 2.1773$. The estimated inflation target for the pre-EMU period is identical to the average inflation rate for the period January 1995 to December 1998, which equals 1.91. As for the EMU period estimated inflation target, it differs slightly from the average inflation (of the corresponding period January 1999 to March 2002), which equals 2.05. This is an indication that the estimated rule fits the data.

Next, for the sake of robustness, it is worth cross-checking the estimation outcome of equation (11) by estimating specification (10) with a different method, namely the Generalized Method of Moments (GMM from now on).[22] As shown in equation (16) the estimates are rather similar- the numbers in the parentheses are t-statistic values, and in table 3 summary statistics are presented.

$$\begin{aligned} i_t &= \underset{(18.9)}{0.635} + \underset{(22.6)}{0.407}\pi_{t+2} - \underset{(-20.5)}{0.17} dummy * \pi_{t+2} + \underset{(32.6)}{0.136} x_t + \underset{(68.8)}{0.692} i_{t-1} + \hat{\varepsilon}_t \quad (16) \\ \text{i.e. } \alpha &= 2.05,\ \beta^{preEMU} = 1.32,\ \gamma = 0.44 \quad (17) \\ \text{and } \alpha &= 2.05,\ \beta^{EMU} = 0.74,\ \gamma = 0.44. \quad (18) \end{aligned}$$

Table 3: Summary statistics for equation (16)

$adj\ R^2$	$Jstat$ $(p-value)$	$Qstat\ 9lags$ $(p-value)$	$Qstat\ 3lags$ $(p-value)$
0.96	20.6 (0.99)	8.06 (0.52)	2.16 (0.53)

The J-statistic tests for the null that the overidentifying restrictions are valid, and the Q-statistic is the Ljung-Box statistic at a specified lag order, which tests for the null hypothesis that there is no autocorrelation up to this lag order.

Let us focus on the EMU period from now on. Equation (13) can be written like equation (2), inserting the estimated π_t^{*EMU} , i.e. $i_t^* = 3.711 + 0.82(\pi_{t+2} - 2.17) + 0.4x_t$, implying that when both inflation and output are on target, the optimal EMU rate would equal 3.711, or 1. 541 in real terms.

Comparing the estimated equation with the original Taylor rule, certain remarks should be made. To begin with, the lagged interest rate has been included in the specification. The constant goes above unity- to account for the higher 'equilibrium' interest rate-, while the size of the inflation response coefficient is considerably lower, falling below the unity threshold. However, taking into account the standard error of the point estimate reported in equation (12), it may be that $\beta^{EMU} > 1$. All the coefficients enter with the right sign and have reasonable size. The hypothesis that $\beta = 1.5$ and $\gamma = 0.5$ cannot be rejected for the pre-EMU period, but it can be rejected for the EMU period.

[22] Here the orthogonality conditions underlying GMM are identical to the assumptions of the TSLS. The optimal weighting matrix is obtained by using the TSLS parameter estimates. The weighting matrix is chosen so that the GMM estimates are robust to heteroskedasticity and autocorrelation of unknown form. The bandwidth selection criterion is set to be the fixed Newey and West and the autocovariances in computing the weighting matrix are weighted according to a Bartlett kernel.

Table 4: Wald Test for equation (11)

Wald Test			
H_0: $\beta = 1.5$ and $\gamma = 0.5$, or			
H_0: $c_2 + c_3$ =0.394995, c_4 =0.131665			
before 1999:1		after 1999:1	
Chi-square	2.31	Chi-square	14
Probability	0.31	Probability	0.001

Concerning the smoothing parameter ρ, it is large enough to confirm the conventional wisdom that the central bank is concerned about smoothing adjustments in the interest rate; it also suggests considerable interest rate inertia. A specification that assumes an immediate adjustment of the actual rate to its target level would, thus, be too restrictive.

With respect to the constant, uncertainty about the long-run interest rate does not cause unstable inflation; rather it results in a mistake in the level of the long-run inflation rate. The size of the inflation mistake depends on the inflation response coefficient. If its value is close to unity, mistakes about the real interest rate will cause bigger mistakes in the inflation rate, this being another reason to keep the parameter well above unity. The estimated coefficient does not plainly exceed unity so as to ensure that when inflation rises, real rates also go up to bring inflation down; its size is much lower than could have been expected given the bank's 'primary objective'.

To conclude the section, note that for the same specification in equation (13), G_QUADR predicts $\beta^{EMU} = 0.96$, $\gamma = 0.3$, G_HP129 $\beta^{EMU} = 1.005$, $\gamma = 0.34$, while G_UNEMPL predicts $\beta^{EMU} = 1.26$, $\gamma = 1.3$ and G_OECD $\beta^{preEMU} = \beta^{EMU} = 1.75$ with γ insignificant. In such a short sample period distortions may arise; if, for instance, during the sample period the central bank is disinflating by pushing up real rates, it is likely that the constant term is overestimated, instead of estimating a higher inflation coefficient. This makes sense since the constant incorporates a relatively high long-run interest rate. Or, more interestingly, suppose that the bank responds aggressively to large deviations of inflation from target but not to small deviations. Then by estimating over a period where inflation does not vary much from its target, one might mistakenly conclude that the bank is not aggressive in fighting inflation, that is, one might mistakenly obtain too low an estimate of the inflation response coefficient. The period 1999:1 to 2002:3 appears to contain some variation in inflation relative to the sample mean (the standard deviation is 0.69), and major distortions do not seem to come up. In any case, lengthening the sample when new data becomes available is highly desirable.

Similar exercises in the literature: the reported estimated coefficients
Clausen & Hayo (2002), with aggregate weighted data from Germany, France and Italy for the period 1979:1-1996:4, find that $\beta = 2.15$, $\gamma = 2.12$ and $\alpha = 3.91$ (with $\rho = 0.86$). Mihov (2001), with data from Germany, France and Italy for the period

1990:3-1998:4, finds that $\beta = 1.83$ and $\gamma = 1.09$ (with $\rho = 0.63$). Gerlach & Schnabel (2000), with aggregate weighted EMU-11 data for the period 1990:1-1998:4, find that $\beta = 2.22$, $\gamma = 0.76$ and $\alpha = 3.89$ (with $\rho = 0.32$). In a forward-looking specification, they find that $c_2 = 1.51$, $c_3 = 0.34$ and $c_1 = 1.95$ (with insignificant ρ).

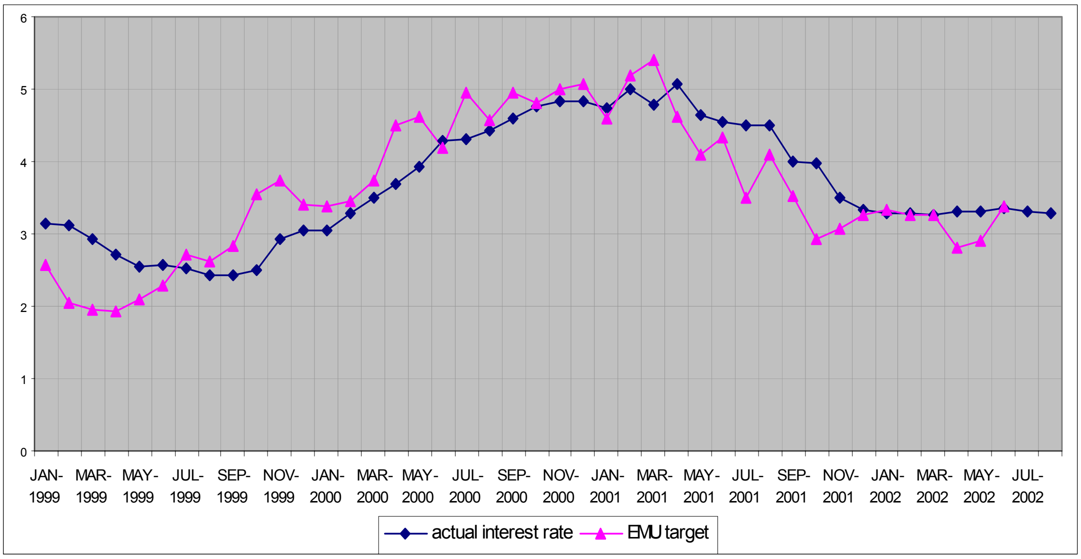
These surveys differ from the present paper most importantly because none of them estimates the interest rate rule with data from the actual EMU period. Gerdesmeier & Roffia (2003) report parameter values of the specification with current inflation and output gap estimated for EMU for various periods: for instance, for 1990- 2002 $\beta = 1.93$, $\gamma = 0.28$, $\alpha = 1.8$ and $\rho = 0.87$ while for 1999-2002, $\beta = 0.45$, $\gamma = 0.30$, $\alpha = 2.6$ and $\rho = 0.72$. Regarding the pre-EMU period, note the close similarity of the results reported in equation (12) with those reported by Gerlach & Schnabel (2000) for the forward-looking specification.

Relation with the actual policy performance To close the section, it is instructive to focus on the actual ECB policy and compare the EMU rule estimated target rate with the actual realization of the short-term interest rate. In figure 2 both rates are displayed. And, although I compare the actual rate with the implied target rate, as opposed to the fitted model that allows for partial adjustment, the target rate captures the direction of movement consistently, and on 10 points the rates virtually coincide.

Compared with the estimated rule, from July 1999 to April 2001 the central bank has pursued a looser policy than justified by the economic conditions. This policy stance has favored countries in danger of recession, like France and Germany, but has aggravated the stress in 'smaller' economies with high inflation and positive output gap. However, during the first six months, and the last twelve the policy was relatively tighter; credibility building in 1999 and reversion of the output gap in 2002 may explain these deviations.[23]

[23] These findings are in accordance with Mihov's (2001) conclusions; he has observed that in mid-1999 the monetary policy was looser than called for by macroeconomic conditions. Similarly, Clausen & Hayo (2002) have observed that actual interest rates were lower than the values suggested by their estimated ECB reaction function for the period January 1999 to July 2000.

Figure 2: Target versus actual rate (EONIA)



6 On the convergence of macroeconomics conditions in the EMU

Even though a Taylor-type interest rate rule is not said to be the optimal rule driving the conduct of monetary policy, it fits the data very well, offering a useful guideline to private agents watching the ECB decisions. In addition, it may be considered as a summary measure of the convergence in macroeconomic conditions, since it weights inflation and output deviations from their target values (Artis (2002)). In this spirit, in the present section I compare the ideal policy stance for the Euro-Area as a whole with the optimal policy for the individual member countries, considering this to be an alternative way to identify the diverging economies in the EMU. My benchmark indicator is the interest rate rule estimated previously.

How 'ideal' is the EMU target rate for the member countries? Figure 3 depicts the disparities in the estimated target interest rates across countries in the first year of the EMU.[24][25] For the majority of the member countries the rule indicated rate is above the EMU one. The divergences on the left of the EMU target are relatively small in size, as they never exceed 50 basis points. However, on the right of the EMU target, divergences are far more conspicuous. Note the outliers, and in particular Ireland for which the difference is 160 basis points.

[24] The values presented are annual averages.
[25] Greece entered the EMU in 2001.

For Germany, Austria, Belgium, France, Finland and Italy the common policy rule target is fairly consistent with the local conditions (a deviation $\leq$ 50 basis points). However, for the Netherlands, Spain, Portugal, and certainly Ireland, it is much lower than local conditions require for overheating to be avoided.

Figure 3: Target rate disparity in 1999

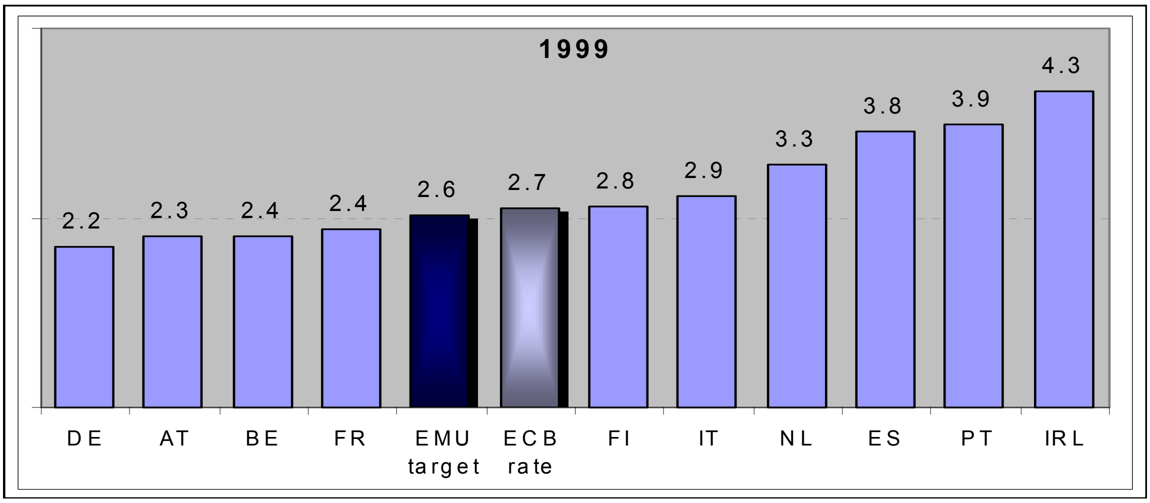


Figure 4 illustrates the differences in optimal target rates in the second year of the EMU. With the exceptions of France, Greece, Germany, Portugal and Austria, for the remaining country members the rule indicated rate is higher than the EMU target rate. On both sides, in most cases, divergences stay bounded below 100 basis points of difference. Ireland is the outstanding exception, as the rule indicated rate exceeds the EMU target by 210 basis points, and then Finland with a deviation of 130 basis points. As for Spain, the deviation from the EMU target is once more almost 100 basis points . In more detail, the EMU target interest rule entails too high a rate for France, and a too low one for Belgium, Spain, Finland and Ireland. For Greece, Germany, Portugal, Austria, Italy and the Netherlands the EMU target is more or less in accordance with local developments, implying that the common policy stance is not likely to provoke imbalances.

Figure 4: Target rate disparity in 2000

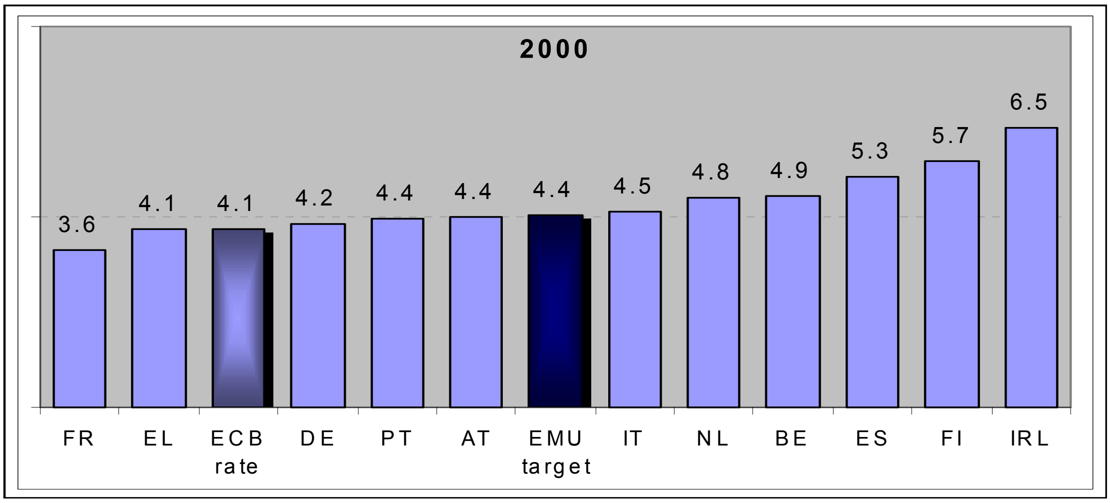
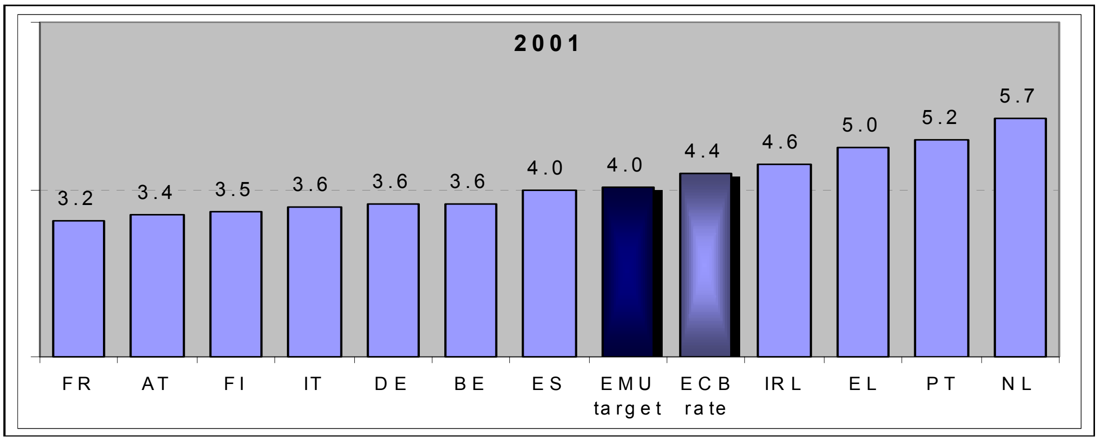


Figure 5 depicts the divergences in the rule indicated interest rates for 2001. For most countries, the deviation is smaller than ± 100 basis points. Exceptions do exist, however. The deviations for France, Ireland and Greece are almost equal to 100 basis points. For the Netherlands the domestic target exceeds the EMU target by 170 basis points and for Portugal by 120 basis points. France and Austria run the risk of enduring a downturn, while Ireland, Greece, Portugal and the Netherlands run the risk of overheating. For Italy, Germany, Belgium and Spain, the EMU target rate is roughly in line with local economic conditions.

Figure 5: Target rate disparity in 2001



A comparison of the dispersion of target rates around the EMU target suggests that deviations were larger in 2000; this being in accordance with the findings of Artis(2002). To complete the story, it shall be emphasized that the HP filter used to measure the output gap suffers from the so-called end-of-sample problem. Focusing, for example, on the Irish case, it is worth noting that one year before the end of the series (in June 2002) the output gap turns negative after years of large positive values. Given the filter's smoothing parameter, and the lack of information on future developments, one cannot be sure whether the observed values indicate a cyclical deviation or a reversal of the trend. A first attempt to incorporate projections of industrial production has not been fruitful. Therefore, the results presented for the last year may be considerably biased.[26]

Thus, in brief, according to the rule indicated optimal rates, throughout the first three EMU years, for Ireland, the Netherlands, Spain and Portugal, and, to a much lesser extent, for France, the predictions of the 'one-size-fits-all' rule are not consistent with the needs of the domestic economies.[27] These deviations are likely to be ignored by the ECB due to the small weight in the area's averages of the countries involved (Dornbusch, Favero & Giavazzi (1998b), Cecchetti, Mark &Sonora (2000))-France excluded. The crucial thing is that the larger the deviation, the greater the implied pressure on the adjustment mechanisms of the economy to avoid either overheating or depression.

The adjustment mechanisms of the member countries In a case where the common monetary policy does not control inflation or stabilize the economy, there is a much greater burden on alternative mechanisms to achieve these objectives. Speaking of mechanisms compensating or supplementing the lack of an independent monetary policy, Sapir & Buti (2001) offer some indicative results. They have estimated the capacity of countries to withstand shocks, and have found that Ireland, Austria, the Netherlands and Finland attain high labor and product market flexibility. On the other hand, Greece, Italy, France and Portugal seem to have the most rigid markets among EMU member countries.[28] They have also observed that France and Germany are very highly similar to the Euro-Area export structure; Belgium, Austria, Spain, Italy and the Netherlands are highly similar; whereas Ireland, Greece, Finland, Luxembourg and Portugal are relatively highly dissimilar to the Euro-Area export exposure. Thus, combining the relative position of individual countries in terms of budgetary policy maneuverability and structural adjustment capability, Ireland and Finland seem fairly well equipped to hold up asymmetric disturbances, which are expected to be frequent given their idiosyncratic economic structures. On the

[26] Nevertheless, according to McMorrow& Roeger(2001), the end-point effects are mainly noticeable for the last 3 or 4 observations. This means that the end-of-sample problem is not relevant in my case, since the sample period finishes in March 2002.

[27] Similarly, Bjorksten & Syrjanen (1999), using the Taylor rule (equation (5) with the constant adjusted), compare the EMU ideal policy stance with the optimal rate for the individual member countries, and find that Ireland, the Netherlands and Spain diverge from the EMU target, being at greatest risk for overheating. On the other side, divergences do not exceed 100 basis points, with Germany at the 'coolest' position.

[28] This grouping is not uncontroversial, but the issue is beyond my interests.

contrary, Italy, Greece and Portugal seem poorly prepared, even though they are exposed to country-specific disturbances. The rest (that is the former DM-zone plus Spain) appear to have middling capability to withstand shocks; but most of them are not prone to experience asymmetric shocks.

7 Concluding remarks

A rule that feeds back from divergence between objectives and long-run sustainable values encapsulates features of the practice of a stability-oriented central bank. And, although it would be misleading to interpret any statistical tests on such a rule as inferences about the actual motives behind the conduct of policy, its success in tracking past policy moves by the central bank is instructive and valuable for the credibility and the good functioning of the monetary policy.

The present paper focuses on such an interest rate rule for the EMU area. It contributes to the literature an analysis of the robustness of the rule to the output gap, an unobservable variable subject to uncertainty, based on estimations which involve all EMU members and making use of the officially published Euro-Area data.

The main finding of the paper is that the size of the rule parameters is robust to various output gap measures and to two alternative inflation measures. In particular, the inflation coefficient is estimated to be above the unity threshold in most of the cases, while the output gap coefficient is estimated to be positive. Furthermore, it has been shown that the target interest rate rule (of the most preferred specification) fits the data very well and tracks the ECB's past decisions surprisingly closely. Lastly, the estimated target rule has been applied as a measure of convergence in macroeconomic conditions across member countries, and it has been proved that the EMU target rate is not consistent with the needs of quite a few member economies.

The paper can be extended along a number of dimensions. In the first place, projections of the industrial production series need to be incorporated so as to cope with the end-of-sample problem. Moreover, it would be instructive to add an output gap measure constructed with a structural method. Last but not least, taking into account the (re-)emergence of sizeable cross-country differences in inflation in the last two years, it would be interesting to explore further the causes of this regional inflation divergence and its implications for the common monetary policy.

APPENDIX

Note for all the tables presented in this appendix: Concerning the first panel, the numbers in parentheses are t-statistic values, "$*$" denotes insignificance at the 95% level. The dummy equals 0 for the pre-EMU period and 1 for the EMU period. Concerning the second panel, in the cells with double entries separated by "/", the first entry refers to the pre-EMU period and the second to the EMU period. The LM Test presented is the Breusch-Godfrey LM Test for serial autocorrelation computed for 6 lags. The numbers in parentheses are probability values for "H_0: no autocorrelation".

Table A1 (Current looking specification-Broad HICP)

$i_t = c_1 + c_2\pi_t + c_3x_t + \rho i_{t-1} + \varepsilon_t$					
	G_QUADR	G_UNEMP	G_HP129	G_HP14	G_OECD
c_1	0.02^* (0.217)	0.048^* (0.47)	0.096^* (1.00)	0.26 (2.47)	0.056^* (0.52)
π_t	0.06^* (1.114)	0.12 (2.24)	0.104 (2.12)	0.1 (2.06)	0.17 (2.54)
x_t	0.02 (2.048)	0.189 (2.46)	0.054 (3.77)	0.079 (4.16)	-0.083^* (-1.75)
i_{t-1}	0.96 (27.863)	0.92 (28.28)	0.919 (30.08)	0.88 (27.76)	0.97 (19.54)
i_{t-6}					-0.097 (-2.16)
$i_t^* = a + \beta\pi_{t+2} + \gamma x_t$					
a				2.23	
β		1.617	1.30	0.85	1.43
γ	0.604	2.55	0.686	0.68	
π^*		2.658	3.298	2.404	3.0
R^2	0.954	0.955	0.959	0.961	0.955
Adj.R^2	0.953	0.954	0.957	0.959	0.953
LM Test	8.8(0.18)	7.7(0.2)	5.2(0.5)	5.3(0.4)	5.8(0.4)

Table A2 (forward-looking specification-Broad HICP)

$$i_t = c_1 + c_2\pi_{t+2} + c_3x_t + \rho i_{t-1} + \varepsilon_t$$

	G_QUADR	G_UNEMP	G_HP129	G_HP14	G_OECD	G_QUADR_Q	G_HP14_Q
c_1	0.09* (0.954)	0.013* (0.12)	0.067* (0.694)	0.24 (2.118)	−0.008* (−0.07)	0.15* (1.28)	0.23* (1.81)
π_{t+2}	0.06* (1.461)	0.14 (2.96)	0.115 (2.51)	0.124 (2.509)	0.2 (3.17)	0.07* (1.73)	0.06* (1.4)
x_t	0.02 (2.172)	0.167 (2.22)	0.051 (3.52)	0.068 (3.32)	−0.103 (−2.21)	0.27 (5.49)	0.19 (3.3)
i_{t-1}	0.93 (31.49)	0.92 (31.43)	0.921 (33.09)	0.877 (29.25)	0.96 (20.23)	0.51 (4.11)	0.7 (5.3)
i_{t-6}					-0.092 (−2.16)		
i_{t-2}						0.40 (3.26)	0.2* (1.5)
$i_t^* = a + \beta\pi_{t+2} + \gamma x_t$							
a				1.92			
β		1.876	1.483	1.01	1.616		
γ	0.36	2.195	0.653	0.55	-0.84	3.2	0.65
π^*		2.238	2.83	2.249	2.59		
R^2	0.959	0.956	0.959	0.959	0.957	0.95	0.932
Adj.R^2	0.957	0.954	0.958	0.959	0.957	0.947	0.928
LM Test	9.3(0.1)	9.7(0.1)	6.3(0.3)	4.2(0.6)	6.4(0.3)	6.9(0.3)	8.6(0.1)

Table A3 (forward-looking specification-Broad HICP)

$$i_t = c_1 + c_2\pi_{t+2} + c_3x_t + \rho i_{t-1} + c_4 dummy + \varepsilon_t$$

	G_QUADR	G_UNEMP	G_HP129	G_HP14	G_OECD
c_1	0.31 (2.34)	0.26* (1.96)	0.32 (2.6)	0.49 (3.608)	0.21* (0.83)
π_{t+2}	0.26 (3.75)	0.28 (4.01)	0.24 (3.95)	0.23 (3.584)	0.24 (3.55)
x_t	0.04 (3.26)	0.22 (2.93)	0.06 (4.23)	0.087 (4.59)	0.001* (0.02)
i_{t-1}	0.83 (18.07)	0.82 (17.5)	0.82 (19.1)	0.786 (17.08)	0.84 (17.29)
c_4	−0.29 (−3.41)	−0.21 (−2.81)	−0.21 (−3.04)	−0.207 (−2.86)	−0.11* (−0.82)
$i_t^* = a + \beta\pi_{t+2} + \gamma x_t$					
a	1.86/0.07	0/-1.23	1.84/0.62	2.32/1.36	
β	1.567	1.59	1.38	1.1	1.606
γ	0.24	1.24	0.34	0.41	
π^*	1.93/2.31	3.06/3.08	2.2/2.22	2.33/2.12	3.05/2.3
R^2	0.96	0.959	0.963	0.964	0.961
Adj.R^2	0.958	0.957	0.961	0.962	0.959
LM Test	5.08(0.5)	7.6(0.2)	4.7(0.5)	5.3(0.4)	7.02(0.3)

Table A4 (forward-looking specification-Broad HICP)							
$i_t = c_1 + c_2\pi_{t+2} + c_3 dummy * \pi_{t+2} + c_4 x_t + \rho i_{t-1} + \varepsilon_t$							
	G_QUADR	G_UNEMP	G_HP129	G_HP14	G_OECD	G_QUADR_Q	G_HP14_Q
c_1	0.29 (2.702)	0.14* (1.35)	0.30 (2.84)	0.509 (4.17)	0.4* (1.17)	0.208* (1.64)	0.26 (2.25)
π_{t+2}	0.47 (5.48)	0.25 (3.19)	0.36 (4.77)	0.35 (4.74)	0.31 (3.07)	0.27 (3.6)	0.29 (3.44)
c_3	−0.25 (−5.19)	−0.07 (−2.01)	−0.14 (−4.05)	−0.14 (−4.06)	−0.13* (−1.16)	−0.11 (−3.10)	−0.15 (−3.52)
x_t	0.07 (5.01)	0.19 (2.79)	0.07 (5.01)	0.102 (5.33)	0.103* (0.73)	0.25 (5.109)	0.31 (5.95)
i_{t-1}	0.76 (16.54)	0.85 (19.1)	0.78 (17.8)	0.73 (15.9)	0.81 (13.4)	0.47 (4.13)	0.406 (3.6)
i_{t-2}						0.36 (3.28)	0.42 (4.07)
$i_t^* = a + \beta\pi_{t+2} + \gamma x_t$							
α	1.22		1.39	1.93			1.64
β	2.01/0.9	1.75/1.2	1.6/1.005	1.35/0.81	1.75	1.77/1.04	1.82/0.8
γ	0.306	1.34	0.34	0.38	0	1.65	1.91
π^*	1.81/2.5	2.79/2.9	2.1/2.28	2.19/2.16	2.45	2.76/3.55	1.78/2.3
R^2	0.965	0.962	0.966	0.966	0.961	0.939	0.949
ADJ.R^2	0.963	0.96	0.964	0.964	0.959	0.934	0.945
LM Test	5.5(0.4)	8.2(0.2)	5.7(0.4)	6.9(0.3)	9.3(0.1)	3.6(0.7)	8.5(0.2)

Table A5 (forward-looking specification-Core inflation)

$$i_t = c_1 + c_2\pi_{t+2} + c_3 x_t + \rho i_{t-1} + \varepsilon_t$$

	G_QUADR	G_UNEMP	G_HP129	G_HP14	G_OECD	G_QUADR_Q	G_HP14_Q
c_1	0.18^* (1.67)	0.309 (2.59)	0.25 (2.4)	0.37 (3.45)	0.39 (2.89)	0.19^* (1.46)	0.24^* (0.06)
π_{t+1}							-0.1^* (-1.1)
π_{t+2}					0.42 (2.68)		
π_{t+6}	0.305 (2.32)	0.401 (3.34)	0.42 (3.51)	0.401 (3.127)		0.26 (2.06)	
x_t	0.018^* (1.85)	0.04^* (0.33)	0.04 (2.57)	0.058 (2.81)	-0.03^* (-0.68)	0.13 (2.64)	0.24 (4.13)
i_{t-1}	0.829 (12.05)	0.82 (12.3)	0.76 (12.2)	0.74 (11.56)	0.89 (14.23)	0.84 (13.1)	0.57 (4.96)
i_{t-2}							0.41 (3.5)
i_{t-9}		-0.06^* (-1.98)			-0.16 (-2.9)		
$i_t^* = a + \beta\pi_{t+2} + \gamma x_t$							
a		1.79	1.05	1.45	1.44		
β	1.79	2.32	1.78	1.56	1.55	1.68	
γ			0.17	0.22		0.85	16.3
π^*	2.39	1.07	1.81	1.81	1.83	2.5	
R^2	0.964	0.965	0.964	0.965	0.96	0.928	0.939
Adj.R^2	0.963	0.964	0.962	0.963	0.957	0.925	0.934
LM Test	5.2(0.5)	4.7(0.5)	6.3(0.4)	5.3(0.5)	12(0.05)	6.9(0.3)	11(0.09)

Table A6 (forward-looking specification-Core inflation)							
$i_t = c_1 + c_2\pi_{t+2} + c_3 dummy * \pi_{t+2} + c_4 x_t + \rho i_{t-1} + \varepsilon_t$							
	G_QUADR	G_UNEMP	G_HP129	G_HP14	G_OECD	G_QUADR_Q	G_HP14_Q
c_1	0.29 (2.45)	0.52 (3.49)	0.24 (2.007)	0.47 (3.25)	0.28* (1.12)	0.22* (1.61)	0.28 (2.09)
π_{t+2}			0.24 (2.104)	0.21 (1.99)			
π_{t+3}					0.43 (2.84)		
π_{t+6}	0.48 (3.71)	0.65 (4.81)				0.39 (2.49)	0.308 (2.039)
c_3	−0.07* (−1.76)	−0.09 (−2.38)	−0.04 (−1.39)	−0.03* (−1.08)	0.04* (0.42)	−0.06* (−1.31)	−0.05* (−1.31)
x_t	0.03 (2.27)	0.09* (0.72)	0.09 (4.405)	0.11 (4.55)	−0.09* (−0.77)	0.21 (3.43)	0.31 (5.95)
i_{t-1}	0.74 (10.6)	0.72 (10.4)	0.83 (13.12)	0.79 (11.4)	0.88 (12.9)	0.81 (11.8)	0.406 (3.6)
i_{t-9}		−0.104 (−2.65)			−0.16 (−2.88)		
$i_t^* = a + \beta\pi_{t+2} + \gamma x_t$							
α	1.15	1.39	1.49	2.25			1.54
β	1.89	1.7/1.48	1.47	1.06	1.57	1.95	1.66
γ	0.128		0.55	0.55		0.91	1.164
π^*	1.658	2/1.54	1.901	1.92	2.73	2.203	1.659
R^2	0.964	0.965	0.958	0.958	0.96	0.931	0.938
Adj.R^2	0.962	0.963	0.955	0.956	0.957	0.926	0.933
LM Test	7.3(0.3)	7.2(0.2)	11(0.09)	12(0.06)	6.9(0.3)	5.1(0.5)	7.2(0.3)

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