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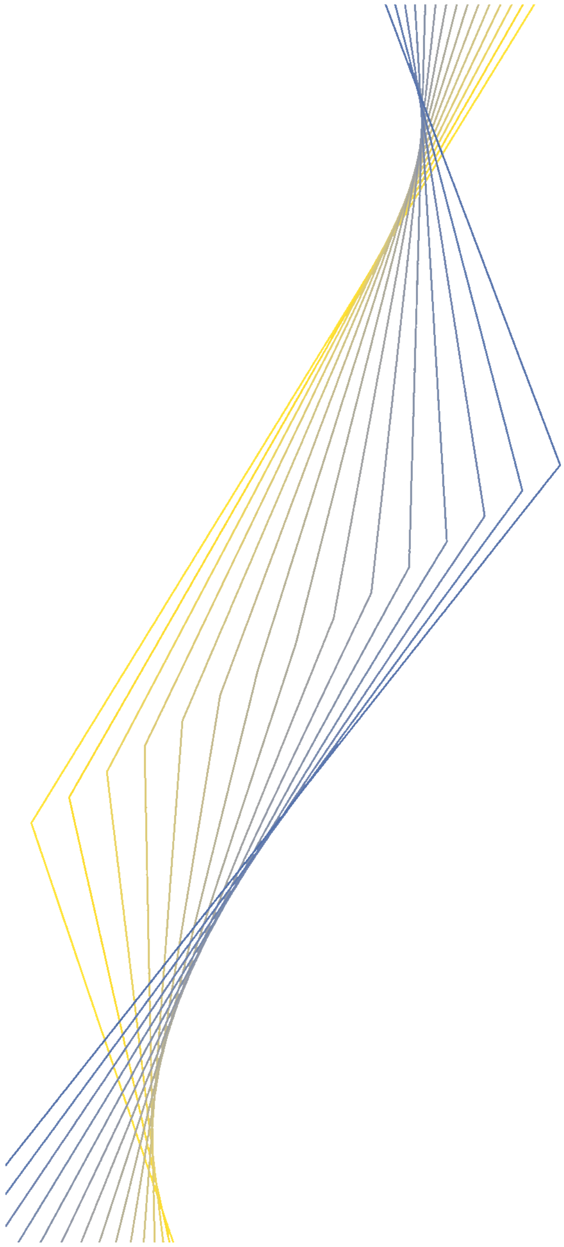

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BY DIETER GERDESMEIER[2] AND BARBARA ROFFIA[2]

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ABSTRACT

This paper contains a set of estimates of reaction functions for the euro area based on a monthly data set starting in 1985. The main aim is to assess the performance of Taylor rules and to evaluate whether alternative specifications based, *inter alia*, on the inclusion of additional variables not contained in the original specification proposed by Taylor 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. An interesting result is that monetary developments (in the form of a money growth gap indicator derived as the deviation of M3 growth from its estimated reference value) enter significantly as an additional variable in a Taylor-like policy rule specification for the euro area.

Key words: Taylor rules; reaction functions; monetary policy; euro area

JEL-classification: E58; F41

NON-TECHNICAL SUMMARY

This paper presents some estimates of monetary policy reaction functions for the euro area. The main focus is devoted to the assessment of the performance of simple Taylor-like reaction functions in tracking interest rate developments in the euro area and to investigate whether these rules can be improved by considering additional economic variables – which were not contained in the original specification proposed by Taylor – to which a fictitious euro area central bank might have responded to when setting its policy rate over the past two decades.

Using the simple version of the Taylor rule which includes a smoothing term, a fictitious euro area central bank would have reacted to changes in (contemporaneous) inflation with a coefficient in the range of 1.9 to 2.2 and to deviations of output (measured in terms of industrial production) from its potential with a coefficient included in a range of 0.1 to 0.5. However, the coefficient on the output gap is slightly affected by the measure employed for real activity. In particular, the use of industrial production instead of GDP leads to lower estimated responses of the interest rate to this variable. Moreover, under certain assumptions, an equilibrium real interest rate of around 3% if an inflation objective of 1.5% is assumed over the whole sample period can be derived for the sample period 1985 to 2002, which might be regarded as a quite plausible value. The equilibrium real interest rate implied by the Taylor rules decreases when only data for the most recent period (i.e. after 1990) are used. Possible explanations could be the fiscal consolidation, the period of disinflation during the 90s and the increasing credibility of the convergence process.

A robustness check is also carried out using alternative specifications of the inflation rate – more precisely the HICP index excluding unprocessed food and energy prices and the GDP deflator – and examining the impact of estimation errors and model uncertainty on the coefficients of the policy rule. In this respect, we consider different measures of the output gap and alternative specifications of the baseline Taylor rule. The evidence suggests that some macroeconomic variables which are not included in the feedback list of the standard Taylor rule turn out to be significant determinants of the euro area interest rates. In particular, the deviation of M3 growth from its reference value (denoted as money growth gap), which is derived taking into account an estimated implicit time-varying normative inflation rate and the growth of potential output over the last two decades, is statistically significant. Moreover, when this money growth gap indicator is included, both coefficients of the output gap and inflation are slightly reduced, with the former becoming even insignificant. A possible interpretation of this result could be that excess money growth contains information for monetary policy which is not (fully) included in the inflation or the output gap terms.

Overall, the general finding is that a Taylor-like rule, which includes an interest rate smoothing, seems to be helpful in describing monetary policy in the euro area over the last two decades. However, when the term describing the smoothing of the interest rate is omitted, the fit of the reaction function deteriorates and the coefficients of both the inflation and the output gap terms decline. It should also be noted that switching from a monthly to a quarterly frequency does not seem to change the results to a considerable extent.

A number of caveats which apply to the present exercise are discussed in the paper. Among the most important ones, it should be kept in mind that the present analysis has been done *ex-post* and it refers in large part to a period when the ECB had not been established yet. Therefore, this exercise should not be misunderstood as attaching any normative value to the respective rules as benchmarks for deciding on monetary policy. Moreover, the framework considered includes only a single equation reduced-form model and it, therefore, excludes any consideration based on multi-equation frameworks.

1. Introduction

The modelling of the central banks' reaction functions, i.e. the systematic relationship between economic developments and the central banks' response to them, has recently attracted increasing attention by macroeconomists who often describe the strategy or the rule followed by a monetary authority by an interest rate reaction function. The reasons which might explain the large interest for estimating the central banks' reaction function could be described as follows. First, such a rule can provide a basis for forecasting changes in the central bank's policy instrument, namely the short-term interest rate. Second, within the context of a macro model, the reaction function could represent an important element to evaluate the central bank's policy and the effects of other policy actions or of economic shocks. Third, when rational expectations are assumed in macro models, knowing the correct reaction function is an important element in estimating the entire model.

A simple rule which has become rather popular both in academic literature and among professional central bank watchers in recent years is the so-called "Taylor rule". This rule specifies that the central bank sets its instrument – the interest rate – in order to react to two key goal variables: the deviations of contemporaneous inflation from an inflation target and the deviations of real output from its long-run potential level.[1] Therefore, by focusing on policy responses to these key variables, the Taylor rule implicitly captures the policy responses to the economic factors that affect the evolution of those key variables.

This paper contributes to this ongoing discussion in so far it aims at estimating Taylor rules for the euro area. Our study fits into the literature which focuses on deriving a reaction function for a "fictitious" central bank in the euro area which may be able to explain its systematic behaviour. It also investigates the explanatory power of additional variables and tests the robustness of the estimated reaction functions to the modelling of the inflation term. One of the main features which distinguish our study from the literature is the monthly data set which, *inter alia*, includes a series of monthly real GDP.[2] Thus it may better represent the decision-making problem a central bank is facing. Given that, since the early 1980s, many European countries have taken a concerted effort to reign in inflation, the estimation of policy rules for the euro area would allow to identify the features of monetary policy which prevailed during an era where policy-making was considered, all in all, to be effective in terms of bringing down inflation to levels consistent with price stability and which continued with the management of the European Central Bank (ECB henceforth).

The present study is organised as follows. Section 2 provides a short review of the main findings of some of the most recent studies which have explored the estimations of Taylor rules and also tackled

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1 Despite its simplicity, the academic literature has shown that Taylor rules have to be interpreted with a grain of salt. It is easy to show that, *inter alia*, the fitted parameters represent a convolution of parameters describing the central banks preferences and those describing the structure of the economy (see Favero, C.A. (2001), p. 36).

2 The details on the method adopted to convert real GDP from quarterly to monthly frequency are provided in Annex B.

various Taylor rule specifications. Section 3 describes the key features of the Taylor rule and the potential problems that might be faced when estimating these rules. The estimation methodology used in this paper and the main specifications of the monetary policy reaction functions considered in this study are described in Section 4. Estimates of these functions are also presented and discussed in that context. The main findings and caveats to the empirical estimations of these reaction functions are summarised in the conclusions.

2. A brief review of the literature

With regard to the euro area, a number of authors have already discussed the potential usefulness of Taylor rules and the main developments in the approaches followed to estimate them. In this paper we will, therefore, only shortly illustrate some specific aspects of some of the most recent studies which have explored the issue of estimating single-equation reaction functions either similar to the original Taylor rule or related to some extended or modified variants of that rule (i.e. expanding the set of explanatory variables on the right-hand side of the Taylor rule).

First of all, there are some studies which have focused on estimating monetary policy reaction functions for single European countries. This type of analysis has been based on the assumption that, for some periods of time, it would not be appropriate to estimate policy rules for the euro area as a whole because of the evolving commitment to the ERM that central banks of the member states had for some time and the collapse of the ERM in 1992 (with the exception of Germany which had always had more control over its domestic monetary policy).

Among these studies, Clarida, Galí and Gertler (1998) (CGG henceforth) paper is worth being mentioned. The study focuses on estimating a forward-looking version (12-months ahead) of the simple reaction functions popularised by Taylor. The authors first analyse a set of monetary policy reaction functions for the G3 (US, Japan and Germany) and for three main European countries (Italy, France and UK, denoted as E3).[3] For the first set of countries they argue that the central banks of the G3 have pursued a form of inflation targeting[4] which is identified as raising nominal interest rates sufficiently to increase real rates when expected inflation increases above its long-run target. Moreover, these banks seem to have responded to anticipated inflation as opposed to lagged inflation. With regard to the E3 countries, it turns out that they have been influenced by German monetary

3 The evaluation of the E3 countries answers the question on how each of those countries would have set its target interest rate if it had applied the same rule as the Bundesbank. This assessment relies on the fact that the Bundesbank had a strong influence on monetary policy within the E3 countries and that these countries were clearly constrained by their ERM commitments before the euro.

4 More explicitly, the authors call it "soft-hearted inflation targeting".

policy.[5] In their study, the authors also focus on more complex rule specifications, namely they consider alternative specifications to the baseline reaction function that permit the central bank to respond to variables other than output and inflation (like lagged inflation, a measure of the gap between actual money stock and the official Bundesbank target or the US Federal Funds rate within the first set of countries and the German short-term interest rate for the E3 countries). The main conclusion is that, with regard to Germany, lagged inflation and the development of monetary aggregates are insignificant, while the coefficients on the US Federal Funds rate and the real rate of the Deutsche Mark vis-a-vis the US dollar are significant but small and leave the estimates of the other coefficients basically unchanged.

Another contribution along these lines is represented by the paper by Faust, Rogers and Wright (2001) (FSW henceforth). This paper belongs to the stream of the literature which focuses in particular on the estimation of a (forward-looking) monetary policy reaction functions for the Bundesbank and uses it as a benchmark to assess the stance of the monetary policy of the ECB since 1999. This approach rests on the idea that the Bundesbank might represent a benchmark for the conduct of monetary policy by the ECB also on the basis of the fact that, in the past, many euro area central banks were following the Bundesbank's policy already before the start of Stage Three of EMU. Comparing the ECB's policy with the one followed by the Bundesbank (i.e. responding in the same way to inflation and the output gap), FSW find that the euro area interest rate is lower than this benchmark. This leads them to conclude that the ECB has put a higher weight on the output gap relative to the weight set by the Bundesbank.

Besides investigating the conduct of monetary policy in the single European countries, many studies are also carried out for the euro area using aggregated euro area data previous to the start of Stage Three of EMU. This type of investigation of the conduct of a "fictitious" central bank in the euro area prior to the establishment of the ECB provides results which are more similar to the analyses which are carried out for the Federal Reserve policy reaction functions.

In this respect, Peersman and Smets (1998) (PS henceforth) confirm the results found by CGG in so far as a forward-looking version of the Taylor rule with interest rate smoothing is able to track German and European short-term interest rates quite well since 1979. The authors also analyse the stabilisation properties of the Taylor rule in a model of the euro area economy, using a weighted average of output and inflation in five euro countries and the German policy rate. Finally, PS also compare the

[5] The authors argue that the assessment of the G3 policy would "*…not only supply lessons for future policy-making in the G3, but it would also provide insight for how the new ECB should manage policy.*" (p. 1034). Moreover, the evaluation of the policy rules for the E3 countries, using the Bundesbank rule as a benchmark, would provide a sense of whether the level of interest rates for each country was reasonable from the perspective of their domestic economic conditions. In this respect, they analyse how the E3 countries would have set their target interest rate if they were applying the same rule as the one used by the Bundesbank, i.e. setting a target interest rate based on (domestic) inflation and output gaps, using the coefficients estimated for the Bundesbank. Such an historical analysis is of interest as it has been often argued that the Bundesbank could be seen as a model for the ECB.

performance of the Taylor rule with an optimal rule – which is derived using a standard loss function[6] – and they find that the Taylor rule behaves quite well, although in the optimal rule the response to the output gap seems to be larger than the one suggested by the Taylor rule.

Another investigation of the performance of (extended) Taylor rules with a focus on euro area data is carried out by Gerlach and Schnabel (1998) (GS henceforth). These authors find that the original Taylor rule with a feedback parameter of 1.5 on inflation and 0.5 on the output gap is able to explain the fall in the average interest rate in the last decade quite well. In particular, they demonstrate that during the period 1990-98, with the exception of the period of the exchange market turmoil in 1992-93, the interest rate in the euro area countries moved closely with output gaps and inflation as would be suggested by the Taylor rule. Moreover, GS – along the lines of CGG – expand the feedback list in the Taylor rule and find that adding other explanatory variables in the Taylor rule does not significantly affect the weights on inflation and the output gap. In relation to this, only the coefficient on the US Federal Funds rate is found to be significant (but negative), while the coefficients related to the growth rate of M3 and the real euro/US dollar exchange rate are found to be insignificant.

It should be noted that most studies on the subject tackled in this paper are based on a slightly modified version of the original simple Taylor rule in so far they include an element of inertia on the right-hand side of the equation. The significance of the lagged interest rate term is generally explained, *inter alia*, by optimal monetary policy inertia or interest rate smoothing behaviour by central banks in their conduct of monetary policy (Woodford, 1999), data uncertainty (Orphanides, 1998) or, according to a recent study by Rudebusch (2002), by the fact that monetary policy inertia is just an illusion and reflects the misspecification of the empirical policy rules which fail to take into account serially correlated shocks and, instead, display substantial partial adjustment.[7]

With regard to the issue of the data which are usually used for estimating monetary policy rules, it should be noted that standard practice in empirical macroeconomics is to employ *ex-post* revised data for this type of investigation. This applies not only to the measure of inflation expectations, but also to data for the output gap.[8] However, this procedure ignores the difficulties associated with the accuracy of initial data and their subsequent revisions. In this respect, Orphanides (2001) shows that real-time policy recommendations may differ considerably from those obtained with *ex-post* revised data. This underlines the importance of the information available to policy makers in real time for the analysis of monetary policy rules. This issue is not dealt with in our present study; however, given the interesting results obtained by Orphanides, it would be worth exploring as future research. In relation to this, it should also be recalled that an additional potential source of complication which is encountered in

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6 Basically, this procedure implies the construction of a macroeconomic model comprising a central bank's loss function out of which the optimal reaction function is derived.

7 Smoothing interest rates might also be consistent with the behaviour of the central bank being subject to a learning process or might result from the fear that *ex abrupto* changes in interest rates might be regarded as being too disruptive to the economy.

8 In a forward-looking specification of the Taylor rule, it is quite common to use realised inflation rates as proxies for the expected inflation rates.

these types of investigation is represented by the difficulty surrounding the estimation of the equilibrium real interest rate.

Finally, Taylor rules can also be calibrated to investigate their explanatory power with respect to the euro area interest rate. Among the studies which deal with this approach, an investigation by Galí (2001), who calibrates a simple benchmark rule for the euro area, should be mentioned. From his exercise, he finds that the ECB has remained substantially below the level implied by the benchmark rule and thus concludes that "…*ECB policy over the period considered may have violated the so-called Taylor principle*".

3. Taylor's original rule and related estimation issues

The monetary policy rule presented by J. Taylor (1993) postulates that the central bank bases the setting of the short-term interest rate on the current situation regarding inflation and the business cycle. More precisely, the rule specifies that the level of the nominal US Federal Funds rate is set equal to the rate of inflation plus an "equilibrium" real funds rate (which is consistent with full employment) plus an equally weighted average of two gaps, a deviation of inflation from its target and the percent deviation of real GDP from an estimated potential level: [9]

(1) $i_t = \pi_t + \overline{r} + 0.5(\pi_t - \overline{\pi}) + 0.5(y_t - \overline{y})$

where i_t represents the policy rate of the central bank (Federal Funds rate in the case of the United States), π_t is the inflation rate, $\overline{r}$ is the equilibrium real interest rate, $\overline{\pi}$ is the inflation target and $(y_t - \overline{y})$ represents the output gap. In his seminal paper, Taylor did not estimate the equation, but he assumed that the weights of the two gaps were equal to 0.5, while the equilibrium real interest rate and the inflation target were both equal to 2%.

He also regarded this rule as being very simple, but, at the same time, being capable of capturing the essential elements of regimes in which the central bank looks at a wider range of variables and relates the policy instrument to current economic conditions. Although estimating the Taylor rule appears, at first glance, to be a very simple task, in fact it can raise a number of practical and theoretical problems.

First, the weights to inflation and output gap must be estimated. However, these weights are both method and sample dependent.

Second, central banks appear to adjust interest rates gradually, by approaching to a desired setting. Therefore, many authors have introduced an additional term in the Taylor rule specification allowing for an interest rate smoothing.

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9 This specification seems to appear, from a certain perspective, more consistent with the Fed's than the ECB's mandate.

Third, broadly based indices such as the Consumer Price Index and the GDP deflator are generally suitable for calculating inflation. It is widely known that there have sometimes been deviations between the different indices, so that the choice of the price index may matter. Moreover, a measure of "underlying inflation" may allow to eliminate purely transitory price movements and capture more long-term price trend.

Moreover, there are also different options available for estimating the output gap. The various methods used – for example, log-linear/quadratic trend, Hodrick-Prescott filter – and the variable considered – real GDP or industrial production – may produce quite major differences which would be reflected directly in the level and the behaviour of the Taylor interest rate rule. Therefore, it is very important to analyse the impact of the estimation error in the output gap on the Taylor rule interest rate. Related to this argument, it should be borne in mind, as already mentioned, that the central bank has to base its monetary policy decisions completely on real-time data and not on the final revised data which are instead normally used to estimate the historical Taylor rule interest rate. As a matter of fact, some of the series are not only subject to subsequent major statistical revisions, but are also released with some time delay with respect to the other series.

Finally, the Taylor rule has also some shortcomings in its design. As initially formulated, it does not take into due account the necessity of modelling the forward-looking behaviour of a central bank. In fact, due to the existence of a lag in the transmission mechanism of monetary policy, the monetary policy decision-makers should be guided by the outlook for prices rather than by the current developments in inflation. On the basis of this argument, the incorporation of additional and more forward-looking information is deemed to be important.

The simple Taylor rule illustrated above serves as a starting point for our present investigation. In the subsequent section, we will also estimate some alternative specifications.

4. Estimates of reaction functions for the euro area

This section presents some estimations of a wide range of reaction functions for the euro area. Our study focuses on euro area data along the lines of the approach embraced in part of the literature. This choice can be justified on several grounds. First of all, euro area policy rules seem to be somewhat more comparable to the Federal Reserve's reaction function than the rules estimated for the individual euro area member states, thus allowing for a more direct investigation to what extent policy rates in the US and in the euro area have historically conformed to the Taylor rate. Second, since the early 1990s the process of monetary convergence in the euro area countries accelerated, so that the investigation of the average interest rate behaviour in these countries could be interpreted as an indicator of the monetary policy stance of the euro area.[10] Third, the use of euro area data implicitly assumes that, before the start of Stage Three of EMU, every country was only looking at its domestic economic conditions, which might seem to be inconsistent with the implementation of the ERM. However, as explained by the study of CGG (1998) mentioned in Section 2, some countries imposed, for some time, strict capital controls which, in essence, provided the respective central banks with some leeway to pursue domestic policy objectives. Fourth, the institutional changes which have occurred since the monetary convergence first, and the establishment of a single monetary policy thereafter, might render the single-country past evidence no longer informative. Finally, there is not sufficient evidence to analyse the euro area as a whole given the fact that only a limited period of time has passed after the start of Stage Three of EMU on 1 January 1999. Against this background, the solution chosen in this study – fully recognising the problems that are implicit in this procedure – is, therefore, to construct measures of aggregate variables at the euro area level starting from the countries forming the euro area for the period before 1999.

The present section is organised as follows. Sub-section 4.1 contains a description of the Taylor-like rule specifications while sub-section 4.2 describes the estimation technique adopted and some diagnostic tests. The main findings of the exercise are discussed in sub-section 4.3, while sub-section 4.4 deals with the derivation of the equilibrium real interest rate from the estimated reaction functions.

4.1 Reaction function specifications

Following the Taylor rule's specification used by CGG and PS, the central bank behaviour can be described by a forward-looking version of the Taylor rule with interest rate smoothing as in the following equation:

$$(2)\qquad i_t = (1-\rho)[\bar{i} + \beta(E(\pi_{t+n}|I_t) - \bar{\pi}) + \gamma E(y_t - \bar{y}|I_t)] + \rho i_{t-1} + \mu_t\,,$$

where $\bar{i}$ is the equilibrium nominal interest rate (i.e. the equilibrium real interest rate plus the inflation objective), π_{t+n} is the annual inflation rate at time ($t+n$), E is the expectation operator and I_t stands for the information available to the central bank when it sets the policy interest rate.[11] This specification of the Taylor rule contains the interest rate smoothing term, on the basis that central banks appear to adjust interest rates in a gradual fashion, slowly bringing the rate towards its desired setting or "target" level.[12] With an inflation parameter larger than unity, the rule indicates that the short-term real interest rate should be increased whenever inflation rises, thus exerting a stabilising effect on inflation. In order to estimate this reaction function, we re-write eq.(2) in terms of realised variables as follows:

[10] See, for instance, Peersman and Smets (1998).

[11] The other variables have been already introduced in Section 3.

[12] Of course, the dynamics of adjustment of the interest rate with respect to its recommended level can take different forms (see, for instance, Judd and Rudebusch (1998)).

(3) $i_t = (1-\rho)\alpha + (1-\rho)\beta\pi_{t+n} + (1-\rho)\gamma(y_t - \overline{y}) + \rho i_{t-1} + \varepsilon_t$,

where $\alpha = (\overline{i} - \beta\overline{\pi})$ and $\varepsilon_t = -(1-\rho)[\beta(\pi_{t+n} - E(\pi_{t+n}|I_t)) + \gamma(y_t - \overline{y} - E(y_t - \overline{y}))] + \mu_t$.

The exercise presented in this section focuses on the following three main aspects.

First, the simple Taylor rule for the euro area as specified in eq.(3) is estimated empirically (and, contrary to what is done in part of the literature, not calibrated). This rule will be denoted as the "baseline specification".

Second, we investigate the robustness of the above results to various forms of uncertainties, which can be divided into two main groups. In relation to the first group, given that the number of variables in the feedback list of the Taylor rule is typically very restricted, the baseline specification is modified to take into account the impact of a wide range of additional explanatory variables on the interest rate. Among these variables, we consider the importance of various exchange rate measures, the influence of the monetary policy in the United States and the deviation of the growth rate of M3 from its reference value.[13] In this case, denoting with x_t the additional explanatory variables, eq.(3) can be re-written as follows:

(4) $i_t = (1-\rho)\alpha + (1-\rho)\beta\pi_{t+n} + (1-\rho)\gamma(y_t - \overline{y}) + (1-\rho)\delta x_t + \rho i_{t-1} + \varepsilon_t$.

Therefore, all these alternative specifications differ only for the term x_t while they all contain the interest rate smoothing term.

Within the second group, alternative measures of the output gap and the inflation term are investigated:

1. Potential output cannot be observed and must be estimated. Therefore, we extend the analysis using different techniques to derive potential output, for both industrial production and real GDP. Apart from simply fitting a trend to the data (both in linear and quadratic terms), we also employ the HP filter method.[14]
2. With regard to alternative measures of inflation, apart from the commonly used HICP index, we also use the GDP deflator, given that in times of lower prices for imported goods, one would get lower rates of inflation based on consumer prices compared to the GDP deflator. Moreover, it may be argued that another measure of inflation, such as the HICP index excluding unprocessed food and energy prices, should be used. The main argument behind this choice is that, if oil price shocks are mainly transitory and do not have a permanent impact on inflation, then monetary policy may not react to those changes in the same way as to changes in, for instance, services or non-energy good prices. Finally, backward-looking and forward-looking Taylor rules will also be

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13 A detailed description of the variables considered is provided in Annex A and Annex B.

14 Structural approaches could also been followed, like for instance estimating potential output in terms of a relationship with future inflation similar to the way a time-varying NAIRU is estimated within the context of a Phillips curve (see Judd and Rudebusch (1998)).

analysed as well as a specification containing the deviation of inflation from its estimated objective.

A robustness check with respect to the results obtained over different sample periods as well as using different sets of instruments in the estimations or different estimation techniques, is carried out.

Figure 1 and Figure 2 below illustrate the alternative estimates for potential output used in our exercise, while Figure 3 shows the developments in different price indices.

Figure 1

Alternative estimates of potential output (based on industrial production)

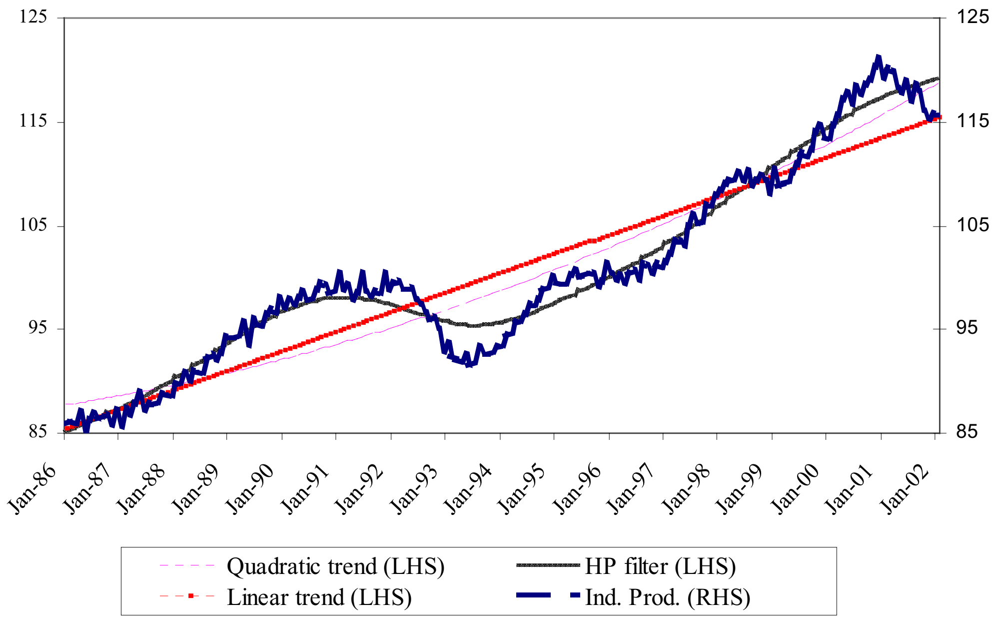


Figure 2
Alternative estimates of potential output (based on real GDP)

Millions of euro

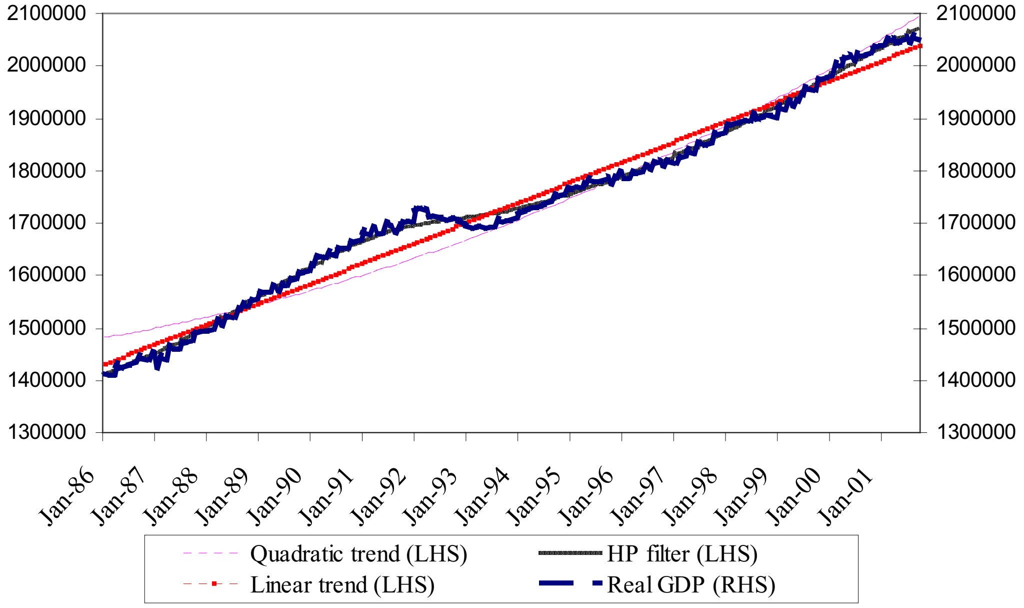
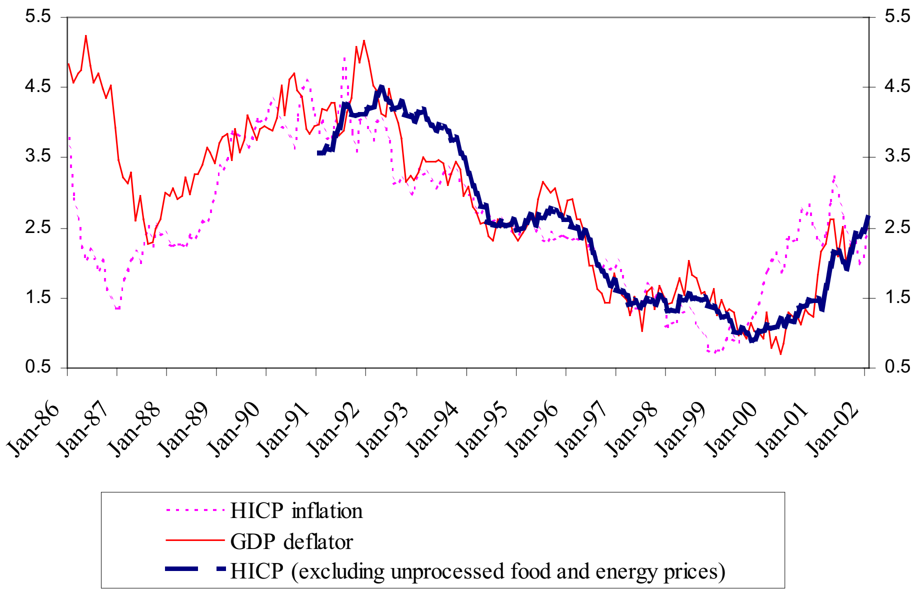


Figure 3
Different measures of inflation for the euro area

Annual percentage change



In Box 1 below we present the set of specifications of the reaction functions which will be estimated. This set is divided into various parts which correspond to the respective tables presented in sub-section 4.3 where the results of the estimations are reported. The first equation in Table 1 refers to the baseline specification while the other equations refer to the baseline specification estimated using different measures of the output gap. Table 2 provides estimates of some extended reaction functions which include additional explanatory variables. Table 3 contains some alternative specifications of the simple Taylor equation which test for the robustness of the results to different measures of the inflation term (namely HICP excluding unprocessed food and energy prices and GDP deflator) and other model specifications (for example, assuming a forward-looking behaviour of the central bank or using quarterly data, etc.). Table 4 contains the estimates of the baseline specification across different sample periods. Based on the assumptions about the (implicit) inflation objective of the fictitious central bank, the exercise can provide an estimate on the pattern of the equilibrium real interest rate in the euro area. In the subsequent tables we investigate the sensitivity of the results to different sets of instrumental variables (Table 5) and to different estimation techniques (Table 6). Finally, the last two tables contain additional estimations of some of the most interesting variants of the baseline rule specification.

Box 1

Specifications of the reaction functions

The following reaction functions – whose results are contained in tables below – are estimated for the euro area:

Table 1

a) eq.(1): $i_t = (1-\rho)\alpha + (1-\rho)\beta\pi_t + (1-\rho)\gamma(y_t - \overline{y}) + \rho i_{t-1} + \varepsilon_t$

b) eq.(2)-(6): $i_t = (1-\rho)\alpha + (1-\rho)\beta\pi_t + (1-\rho)\gamma(y_t - \overline{y}^*) + \rho i_{t-1} + \varepsilon_t$

Table 2

c) eq.(7)-(19): $i_t = (1-\rho)\alpha + (1-\rho)\beta\pi_t + (1-\rho)\gamma(y_t - \overline{y}) + (1-\rho)\delta x_t + \rho i_{t-1} + \varepsilon_t$

Table 3

d) eq.(20): $i_t = (1-\rho)\alpha + (1-\rho)\beta\pi_{t+6} + (1-\rho)\gamma(y_t - \overline{y}) + \rho i_{t-1} + \varepsilon_t$

eq.(21): $i_t = (1-\rho)\alpha + (1-\rho)\beta\pi_{t-12} + (1-\rho)\gamma(y_t - \overline{y}) + \rho i_{t-1} + \varepsilon_t$

eq.(22): $i_t = (1-\rho)\alpha + (1-\rho)\beta(\pi_t - \overline{\pi}) + (1-\rho)\gamma(y_t - \overline{y}) + \rho i_{t-1} + \varepsilon_t$

eq.(23): $i_t = (1-\rho)\alpha + (1-\rho)\beta\pi^*_{t+12} + (1-\rho)\gamma(y_t - \overline{y}) + \rho i_{t-1} + \varepsilon_t$

eq.(24)-(25): $i_t = (1-\rho)\alpha + (1-\rho)\beta\pi^*_{t-12} + (1-\rho)\gamma(y_t - \overline{y}) + \rho i_{t-1} + \varepsilon_t$

eq.(26): $i_t = \alpha + \beta\pi_t + \gamma(y_t - \overline{y}) + \varepsilon_t$

eq.(27): $i_t = (1-\rho)\alpha + (1-\rho)\beta\pi_t + (1-\rho)\gamma(y_t - \overline{y}) + \rho i_{t-1} + \varepsilon_t$

eq.(28): $i_t = (1-\rho)\alpha + (1-\rho)\beta\pi_t + (1-\rho)\gamma(y_t - \overline{y}^*) + \rho i_{t-1} + \varepsilon_t$

Table 4

e) eq.(29)-(33): $i_t = (1-\rho)\alpha + (1-\rho)\beta\pi_t + (1-\rho)\gamma(y_t - \overline{y}) + \rho i_{t-1} + \varepsilon_t$

Table 5

f) eq.(34)-(36): $i_t = (1-\rho)\alpha + (1-\rho)\beta\pi_t + (1-\rho)\gamma(y_t - \overline{y}) + \rho i_{t-1} + \varepsilon_t$

Table 6

g) eq.(1): $i_t = (1-\rho)\alpha + (1-\rho)\beta\pi_t + (1-\rho)\gamma(y_t - \overline{y}) + \rho i_{t-1} + \varepsilon_t$

eq.(26): $i_t = \alpha + \beta\pi_t + \gamma(y_t - \overline{y}) + \varepsilon_t$

eq.(13): $i_t = (1-\rho)\alpha + (1-\rho)\beta\pi_t + (1-\rho)\gamma(y_t - \overline{y}) + (1-\rho)\delta x_t + \rho i_{t-1} + \varepsilon_t$

eq.(37): $i_t = \alpha + \beta\pi_t + \gamma(y_t - \overline{y}) + \delta x_t + \varepsilon_t$

eq.(5): $i_t = (1-\rho)\alpha + (1-\rho)\beta\pi_t + (1-\rho)\gamma(y_t - \overline{y}^*) + \rho i_{t-1} + \varepsilon_t$

Table 7

h) eq.(22b,c): $i_t = (1-\rho)\alpha + (1-\rho)\beta(\pi_t - \overline{\pi}) + (1-\rho)\gamma(y_t - \overline{y}) + (1-\rho)\delta x_t + \rho i_{t-1} + \varepsilon_t$

Table 8

i) eq.(37): $i_t = \alpha + \beta\pi_t + \gamma(y_t - \overline{y}) + \delta x_t + \varepsilon_t$

eq.(38): $i_t = (1-\rho)\alpha + (1-\rho)\beta\pi_t + (1-\rho)\gamma(y_t - \overline{y}) + (1-\rho)\delta x_t + (1-\rho)\lambda z_t + \rho i_{t-1} + \varepsilon_t$

Note: the "" next to the explanatory variables in some of the formulas in Table 1,Table 3 and Table 6 denotes an alternative measure of the correspondent variable with respect to the measure used in the baseline specification.*

The data set used for the estimations includes monthly data generally covering the period 1985:01-2002:02.[15] The values of the coefficients (together with the standard errors[16]) of α, ρ, β and γ (and, in addition, δ, λ whenever it applies) are reported in the tables in Section 4.3. When the *n*-period ahead inflation is used as explanatory variable, the ending point is *n* months prior to the latest available data.[17] In the same tables we also report the value of the equilibrium real interest rate (see column 6). There are various ways of deriving measures of the equilibrium real interest rate. One possibility would be to use a simple weighted average of the *ex-post* real interest rates for the euro area countries. A similar method which, however, takes into account the fact that some European countries may have suffered from high *ex-post* real interest rates due to low credibility of their monetary policy, consists in purging this part related to the low credibility from the *ex-post* real interest rate by correcting the average realised real interest rate by the average depreciation of the exchange rate of the European countries against the Deutsche Mark. This method would yield a sort of "credibility adjusted" equilibrium real interest rate.[18] In the present study, the derivation of our measure of the equilibrium real interest rate is carried out taking into account the definition of price stability of the ECB. On this basis, we assume a constant value of the inflation objective equal to 1.5% and thus calculate the implicit value which is also based on the estimated coefficients related to the different policy rules.[19] While this method has the advantage of deriving the value of the equilibrium real interest rate consistently with the Taylor rule framework, it, however, suffers from the fact that it is based on constant parameters and on a fixed value of the inflation objective, thus yielding a constant

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15 The cut-off date of the data set is end of April.

16 The standard errors of the coefficient estimates are consistent with those which would be obtained using the delta method.

17 It should be noted that the values of future inflation are not determined by means of a model but are chosen assuming perfect foresight.

18 See, for instance, Gerlach and Schnabel (1999).

19 The formula for calculating the equilibrium real interest rate can be derived by eq.(3) and is equal to $\left[(\beta-1)\overline{\pi}+\alpha\right]$.

value of the equilibrium real interest rate.[20] Finally, in Section 4.4 below we follow a different method by relaxing the assumption of constant inflation and thus deriving a time-varying equilibrium real interest rate using time-varying/recursive methods.

4.2 The estimation technique and diagnostic tests

To estimate the parameters vector, the Generalised Method of Moments (GMM) is used. This technique nests many common estimators and is chosen in order to avoid a possible correlation between the right-hand variables and the residuals (so-called simultaneity bias).

In the literature, Taylor rules of the kind of eq.(1) – i.e. without a forward-looking specification – are sometimes estimated by running a simple Ordinary Least Squares (OLS) regression instead of using GMM. However, in case not all the right-hand side variables were exogenous, OLS estimates would be biased and inconsistent. Therefore, it seems advisable to test whether, in the baseline specification of the Taylor rule, the interest rate is not endogenously determined by inflation and the output gap. For this purpose, we run the Hausman and the LM tests which clearly rejected the hypothesis of consistent OLS estimates.[21] On this basis, all the estimations are carried out adopting the GMM methodology.

With regard to the choice of the instruments, they need to be predetermined, i.e. being dated *t* or earlier. In this context, lagged values of the explanatory variables appear to be natural candidates, but, however, one should be careful not to use too many lags or many instruments. Good instruments have two properties. First, the set of instruments should be detected by choosing a vector of variables within the central bank's information set at the time it chooses the interest rate (i.e. at time *t*) that are orthogonal to the error term. Second, at the same time, they should not only be uncorrelated with the residual term, but they should also be strongly correlated with the right-hand side variables. Possible elements include any lagged variables that help forecast inflation and output as well as any contemporaneous variables that are uncorrelated with the current interest rate shock. The instrument set used in this paper includes up to 6 lagged values of the output gap and the inflation rate for the baseline specification, and in addition up to 6 lagged values of the additional explanatory variables (see Table 2, column 5).[22]

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[20] However, a constant value for this variable could also be derived using the second method described above when setting the average rate of depreciation equal to zero.

[21] The null hypothesis of no bias in the OLS estimates can be rejected with a probability of 0.003 in the case of the Hausman test and 0.001 in the case of the LM test.

[22] With regard to the choice of the set of Instrumental Variables (IV) used in this paper, our selection is in line with the literature. The impact on the coefficients estimates following a selection of different sets of instruments is illustrated in Table 6. However, it must be remembered that, on the one hand, using a large number of instruments would increase the number of overidentifying restrictions and lead to a smaller asymptotic covariance while, on the other hand, bad instruments would lead to seriously biased estimates especially in small samples.

The weighting matrix is chosen using the method suggested by Newey and West (1987), who have proposed a general covariance estimator that is consistent in the presence of both heteroskedasticity and autocorrelation of unknown form (so-called *HAC Covariances*).[23]

It should be noted that GMM requires no information about the exact distribution of the error term which implies that the normality assumption – being a crucial precondition for many other estimation procedures – is not required. All that is required is that the orthogonality conditions hold.[24]

In the tables we also report the results related to the *J-statistic* (see column 7). The J-statistic is used to test the validity of overidentifying restrictions (i.e. when the number of instruments is greater than the number of parameters to be estimated). Under the null hypothesis that the overidentifying restrictions are satisfied, the J-statistic times the number of regression observations is asymptotically χ^2 distributed with degrees of freedom equal to the number of overidentifying restrictions.[25] The tables also contain the results of the *Wald test* which assesses the validity of the joint restrictions on the coefficients of the explanatory variables. In essence, it tests whether the coefficients on inflation and the output gap are jointly not significantly different from the original values suggested by Taylor, namely 1.5 and 0.5 respectively.

Finally, with regard to testing the parameter constancy, we carried out the *Cusum* and *Cusum of Squares tests* of the residuals (see Annex C).[26] Although these tests seem to indicate the presence of parameter and variance instability at some points of time, they are suggestive of no movements outside the critical lines towards the major part of the sample, thus suggesting that the residual variance is somewhat stable.[27]

4.3 Estimation results

This sub-section presents and discusses the results of the estimations of the policy rules specifications which have been described in sub-section 4.1. Looking at the figures reported in the tables below, the following results are worth mentioning.

1. **<u>Inflation and output gap weights in the baseline specification</u>**

With regard to the baseline specification (eq.(1) in Table 1), the weights on inflation and the output gap are estimated to be 1.93 and 0.28, respectively. The results of the Wald test suggest that these

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[23] Using the Newey-West HAC consistent covariance estimates does not change the point estimates of the parameters, but only the estimated standard errors.

[24] "The key advantage of GMM is that it requires specification only of certain moment conditions rather than the full density", see Hamilton (1994), p. 409.

[25] For further detail, see Johnston and DiNardo (1997) p. 337 and *ff.*

[26] See Brown, Durbin and Evans (1975).

[27] For the calculation of the critical values, see Johnston and DiNardo (1997), p. 519.

coefficients are in line with the original coefficients proposed by Taylor. The corresponding value for the equilibrium real interest rate is 3.2% (3.7%) if an inflation objective of 1.5% (2%) is assumed.

However, the coefficient values do not seem to be fully robust with respect to the measurement of the output gap. For instance, when the HP filter method is applied to industrial production (and also to real GDP), the coefficients of inflation and the output gap are jointly significantly different from the original values advocated by Taylor (i.e. the null hypothesis of the Wald test is rejected, see eq.(2) and eq.(5)).

Figure 4 below reports the fitted interest rate based on the estimated baseline model and the actual interest rate for the euro area. The figure shows that the estimated interest rate nicely tracks the behaviour of the actual interest rate which, to a significant extent, is likely to be due to the inclusion of the lagged interest rate (i.e. the smoothing term).

Figure 4
Actual and fitted interest rate for the euro area

Percentage points

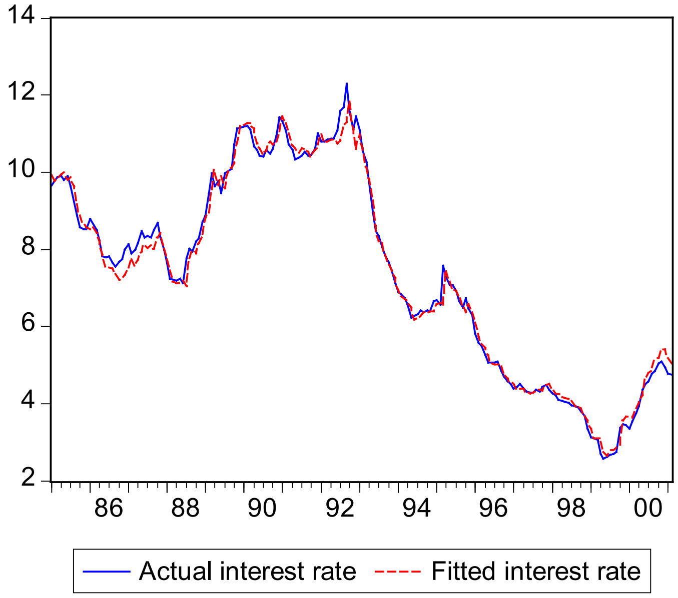

Table 1

Estimates of Taylor rules in the euro area – sample period 1985:01-2002:02

No. of eq.	Specification	α (1)	ρ (2)	β (3)	γ (4)	δ (5)	$\bar{r}$ (6)	$\bar{R}^2$	J-test (7)	Wald Test [1]
Baseline specification										
1 GMM	Simple Taylor rule	1.80 (0.67)	0.87 (0.05)	1.93 (0.25)	0.28 (0.13)	(-)	3.20	0.99	0.024	1.93 (0.15)
Alternative measurements of the output gap										
2 GMM	HP-filter on ind. prod. [2]	1.21 (0.53)	0.82 (0.07)	2.17 (0.19)	0.28 (0.21)	(-)	2.97	0.98	0.015	12.4 (0.00)
3 GMM	Linear trend of ind. prod.	1.31 (0.59)	0.85 (0.06)	2.13 (0.22)	0.13 (0.10)	(-)	3.01	0.98	0.018	14.5 (0.00)
4 GMM	Quadratic trend on real GDP	1.50 (0.56)	0.84 (0.06)	2.07 (0.23)	0.21 (0.14)	(-)	3.11	0.98	0.037	3.58 (0.03)
5 GMM	HP-filter on real GDP	1.18 (0.54)	0.84 (0.06)	2.16 (0.20)	0.53 (0.64)	(-)	2.92	0.98	0.019	11.1 (0.00)
6 GMM	Linear trend on real GDP	1.89 (0.71)	0.86 (0.05)	1.89 (0.28)	0.38 (0.23)	(-)	3.23	0.99	0.025	2.34 (0.31)

Notes to Table 1:

The equations are estimated using the Generalised Method of Moments. When not specified otherwise, the instrument set includes lagged values (up to 6 lags) of inflation and the output gap. Industrial production is used to capture output developments on a monthly frequency, apart from the cases when the use of real GDP is explicitly mentioned. In the baseline case, a quadratic trend is used to calculate potential output (and, therefore, the output gap).

[1] p-value, null hypothesis that the coefficients on the output gap and the inflation term are jointly not statistically different from 0.5 and 1.5, respectively.

[2] When potential output is computed using the Hodrick-Prescott filter, the smoothing parameter is set equal to 14400 for monthly data and 1600 for quarterly data.

2. Sensitivity of the results to the addition of other explanatory variables

The baseline specification is amended to include some additional variables which might have played, at least in certain periods, an important role in the interest rate setting of a central bank (see Table 2). The following interesting results have been found.

Firstly, when including the **euro effective exchange rate** and the **euro exchange rate vis-à-vis the US dollar** – both in nominal and real terms (see eq.(7) - eq.(10)) – it turns out that, as expected, the short-term interest rate has positively responded to a depreciation of these measures of the exchange rate. However, the coefficients of these variables are not found to be significant on a statistical basis, a result which is consistent with the earlier findings by Gerlach and Schnabel (1999). Along the same lines, also the **world commodity prices** and the US monetary policy (the latter measured by the **US Federal Funds rate**) are not found to have any additional significant influence on the level of the euro area interest rates.

Secondly, a very interesting result is represented by the significance of the coefficient of the deviation of M3 growth from its reference value which is denoted as **money growth gap indicator**. This variable turns out to have a positive impact on the euro area interest rate. This result is valid not only when the reference value for monetary growth is set to be equal to 4½% over the whole sample period (*cf.* money growth gap (a) in eq.(12)), but also when the reference value prior to 1999 is calculated as time-varying and derived as the sum of the estimated annual inflation objective and potential output growth minus the medium-term velocity trend (*cf.* money growth gap (b) in eq.(13)).[28] This finding would imply that, prior to 1999, a fictitious central bank in the euro area can be portrayed as having responded to an excess monetary growth by increasing the interest rate.

Thirdly, we consider whether some measures of stock prices might have influenced the response of the monetary authority. For this purpose, we use the **DJ Euro Stoxx 50** index both in nominal and real terms, and also corrected for the growth of the economic activity.[29] It turns out that changes in nominal and real stock prices corrected for industrial production growth are also significant and enter with a positive sign the Taylor rule (see eq.(16) and eq.(18)). However, in this case the implied equilibrium real interest rate decreases to a rather low level, thus suggesting a need for further investigation.

Finally, as a general conclusion, it can be noticed that the parameter estimates for inflation and the output gap are basically unaffected by the inclusion of the additional variables and remain, in general, strongly significant.

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[28] See Annex B for further details.

[29] The correction of the DJ Euro Stoxx 50 for the growth in the economy is done in order to construct a measure for the growth in stock prices not explained by real growth.

Table 2

Estimates of Taylor rules in the euro area – sample period 1985:01-2002:02

No. of eq.	Specification	α (1)	ρ (2)	β (3)	γ (4)	δ (5)	$\bar{r}$ (6)	$\bar{R}^2$	J-test (7)	Wald Test [1]
	Additional explanatory variables									
7 GMM	Nom. euro eff. exchange rate [2]	0.88 (0.81)	0.95 (0.02)	1.59 (0.37)	0.72 (0.28)	-0.17 (0.11)	1.78	0.99	0.091	0.86 (0.42)
8 GMM	Real euro eff. exchange rate	0.80 (0.80)	0.95 (0.02)	1.70 (0.37)	0.68 (0.25)	-0.18 (0.10)	1.85	0.99	0.092	0.77 (0.46)
9 GMM	Nominal euro exchange rate vis-à-vis US $	2.13 (1.29)	0.95 (0.03)	1.57 (0.61)	0.87 (0.59)	-0.02 (0.04)	2.99	0.99	0.096	1.09 (0.34)
10 GMM	Real euro exchange rate vis-à-vis US $	2.13 (1.29)	0.95 (0.03)	1.55 (0.59)	0.87 (0.58)	-0.02 (0.04)	2.96	0.99	0.096	0.95 (0.39)
11 GMM	Commodity prices	1.58 (2.16)	0.98 (0.03)	1.31 (1.43)	1.24 (1.54)	0.22 (0.30)	2.05	0.99	0.056	0.29 (0.75)
12 GMM	Money growth gap (a) [3]	2.05 (0.59)	0.87 (0.04)	1.50 (0.27)	0.24 (0.10)	0.49 (0.16)	2.80	0.99	0.035	3.45 (0.03)
13 GMM	Money growth gap (b) [4]	1.51 (0.69)	0.92 (0.03)	1.86 (0.30)	0.26 (0.18)	0.41 (0.17)	2.80	0.99	0.050	1.21 (0.30)
14 GMM	Federal Funds rate	1.54 (1.41)	0.92 (0.02)	1.81 (0.28)	0.41 (0.18)	0.04 (0.20)	2.78	0.99	0.056	0.59 (0.55)
15 GMM	DJ Euro Stoxx 50 [5]	-1.71 (1.04)	0.95 (0.02)	2.39 (0.32)	0.53 (0.28)	0.06 (0.03)	0.38	0.99	0.065	4.65 (0.01)
16 GMM	DJ Euro Stoxx 50 corrected for ind. prod. growth	-1.29 (0.93)	0.95 (0.02)	2.30 (0.34)	0.54 (0.28)	0.06 (0.03)	0.67	0.99	0.068	3.89 (0.02)
17 GMM	DJ Euro Stoxx 50 corrected for real GDP growth	0.07 (0.70)	0.91 (0.02)	2.31 (0.25)	1.34 (0.67)	0.01 (0.01)	1.90	0.99	0.050	12.06 (0.00)
18 GMM	Real DJ Euro Stoxx 50 corrected for ind. prod. growth	-1.29 (0.93)	0.95 (0.02)	2.36 (0.33)	0.54 (0.28)	0.06 (0.03)	0.76	0.99	0.068	4.27 (0.02)
19 GMM	Real DJ Euro Stoxx 50 corrected for real GDP growth	0.07 (0.70)	0.91 (0.02)	2.31 (0.26)	1.84 (0.67)	0.01 (0.01)	2.03	0.99	0.050	11.40 (0.00)

Notes to Table 2:

The equations are estimated using the Generalised Method of Moments. When not specified otherwise, the instrument set includes lagged values (up to 6 lags) of inflation and the output gap. Industrial production is used to capture output developments on a monthly frequency, apart from the cases when the use of real GDP is explicitly mentioned.

[1] p-value, null hypothesis that the coefficients on the output gap and the inflation term are jointly not statistically different from 0.5 and 1.5, respectively.
[2] All exchange rate variables used in the estimations are measured in terms of annual changes. In all the equations which include the exchange rate as an additional right-hand variable, the list of instruments is expanded by adding lagged values of M3 growth and the commodity prices.
[3] The money growth gap (a) indicator is measured by the deviation of annual M3 growth from the ECB's reference value for monetary growth (4½% per annum).
[4] The money growth gap (b) indicator is measured by the deviation of the annual M3 growth from a time-varying reference value based on the ECB's definition of price stability, the growth rate of potential output and the medium-term velocity trend based on the Calza-Gerdesmeier-Levy (CGL) money demand model (see Annex B for further detail).
[5] The DJ Euro Stoxx 50 in eq.(15) is measured as annual growth rates in nominal terms. In eq.(16) and eq.(17) the additional indicators are derived as the differences between the annual changes in the DJ Euro Stoxx 50 and in industrial production, while eq.(18) and eq.(19) refer to the differences between annual changes in the DJ Euro Stoxx 50 and real GDP growth.

3. Sensitivity of the results to a different modelling of the inflation term

In Table 3 we allow for a different modelling of the inflation term by hypothesising that the central bank may react (a) either to past inflation (i.e. it is backward-looking, see eq.(21))[30] or (b) that central banks can only affect inflation with some lags (i.e. adopting a forward-looking Taylor rule, see eq.(20)). In both these cases, the coefficient on the inflation term turns out to be significantly different from zero and not statistically different from 1.5. Moreover, these results are robust to the choice of modelling the inflation term as the difference between the euro area inflation rate and the central bank's average implicit "inflation objective" (see eq.(22)).[31, 32]

In the same table the robustness of the Taylor rule is also tested with respect to the measurement of the inflation variable. In this respect, estimates referring to an inflation measure based either on the HICP index excluding unprocessed food and energy prices or on the GDP deflator are also reported. The use of the HICP index excluding unprocessed food and energy prices inflation measure is based on the hypothesis that rises in oil prices combined with a depreciation of the euro exchange rate have been an important source of increase in the HICP inflation in the euro area. The results we obtain using this measure of inflation suggest a higher weight on the inflation term than in case the headline index is used (see eq.(23) and eq.(24)).[33] Moreover, it is interesting to note that the coefficient on the output gap is lower. The same applies when the GDP deflator is used as a price measure (see eq.(25)).[34]

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30 However, one could argue that the backward-looking behaviour is a little implausible, given that is inconsistent with the fact that central banks, usually facing long and variable lags of transmission, need to respond in due time.

31 See also Annex B for further detail on the construction of the inflation objective.

32 In this case, the formula for calculating the equilibrium real interest rate is equal to $(\alpha - \bar{\pi})$.

33 However, it must be noted that the regressions for inflation measured in terms of the HICP index excluding unprocessed food and energy prices are run on a shorter sample period (starting in January 1991) due to the lack of data for the euro area. This might have influenced the final estimates.

34 For the GDP deflator, only a backward-looking equation is found to perform satisfactorily. In the case of a forward-looking specification, convergence problems arise.

4. Sensitivity of the results to the exclusion of the smoothing term and a change in the frequency

We also investigate the performance of the original Taylor rule which omits the smoothing of the interest rate. In this case, the coefficient of inflation is approximately 2 and significantly different from 1.5 while the response to output is almost negligible (see eq.(26)).

The results of the baseline specification are not significantly affected when quarterly data are used (see eq.(27) and eq.(28)). In this case, the coefficient on inflation (output gap) is slightly higher (lower) when using industrial production compared to real GDP.

As a general observation, the explanatory power of all the models is rather high. In the literature this is usually attributed to the inclusion of the smoothing in interest rates. Our results confirm this view. Indeed, it can be noted that, irrespectively of the estimation method employed (see also the results in Table 6), the explanatory power of the equation decreases substantially when the lagged interest rate is omitted.

Table 3

Estimates of Taylor rules in the euro area – sample period 1985:01-2002:02

No. of eq.	Specification	α (1)	ρ (2)	β (3)	γ (4)	δ (5)	$\bar{r}$ (6)	$\bar{R}^2$	J-test (7)	Wald Test [1]
Alternative specifications										
20 GMM	Forward-looking inflation (t+6)	1.73 (2.34)	0.97 (0.01)	1.82 (0.99)	0.77 (0.55)	(-)	2.95	0.99	0.051	0.55 (0.58)
21 GMM	Backward-looking inflation (t-12)	1.79 (2.57)	0.98 (0.02)	1.53 (1.08)	1.39 (1.10)	(-)	2.59	0.99	0.042	0.67 (0.51)
22 GMM	Deviation of infl. from its target	5.50 (0.48)	0.93 (0.04)	1.91 (0.45)	0.38 (0.24)	(-)	4.00	0.99	0.029	0.41 (0.66)
23 GMM	HICP (excl. unpr. food & energy prices) forward-look. infl. (t+12)	0.04 (0.52)	0.90 (0.02)	2.57 (0.20)	0.13 (0.13)	(-)	2.40	0.99	0.027	29.7 (0.00)
24 GMM	HICP (excl. unpr. food & energy prices) backward-look. infl. (t-12)	0.64 (0.58)	0.93 (0.01)	2.05 (0.29)	0.90 (0.15)	(-)	2.22	0.99	0.039	3.73 (0.03)
25 GMM	GDP deflator backward-look. infl. (t-12)	0.58 (0.42)	0.86 (0.03)	2.09 (0.14)	0.51 (0.07)	(-)	2.22	0.99	0.036	9.17 (0.00)
26 GMM	No lagged interest rate	1.61 (0.55)	(-)	2.08 (0.18)	0.06 (0.05)	(-)	3.23	0.67	0.031	66.2 (0.00)
1 GMM	Simple Taylor rule (monthly)	1.80 (0.67)	0.87 (0.05)	1.93 (0.25)	0.28 (0.13)	(-)	3.20	0.99	0.024	1.93 (0.15)
27 GMM	Baseline spec. (quarterly data) – ind. prod.	1.33 (0.94)	0.71 (0.18)	2.11 (0.34)	0.30 (0.34)	(-)	3.00	0.95	0.001	3.23 (0.20)
28 GMM	Baseline spec. (quarterly data) – real GDP	1.99 (1.02)	0.75 (0.16)	1.79 (0.42)	0.77 (0.91)	(-)	3.18	0.96	0.014	1.26 (0.53)

Notes to Table 3:

The equations are estimated using the Generalised Method of Moments. When not specified otherwise, the instrument set includes lagged values (up to 6 lags) of inflation and the output gap. Industrial production is used to capture output developments on a monthly frequency, apart from the cases when the use of real GDP is explicitly mentioned.

[1] *p-value, null hypothesis that the coefficients on the output gap and the inflation term are jointly not statistically different from 0.5 and 1.5, respectively.*

5. Sensitivity of the results to different sample periods

In Table 4 we relax the assumption of parameter constancy by estimating the baseline specification over different sample periods.

With regard to the inflation term, the response coefficient of the central bank seems to have decreased over time since 1990.[35] With respect to the output gap, its coefficient remains always below 0.6 but does not show any clear pattern.

Finally, the value of the implied equilibrium real interest rate is always lower when estimated over more recent sample periods compared to its equivalent for the whole sample period.

35 It should be noted that, however, the time span of three to five years is basically too short to reliably estimate the coefficients.

Table 4

Estimates of Taylor rules in the euro area – sample period 1985:01-2002:02

No. of eq.	Specification	α (1)	ρ (2)	β (3)	γ (4)	δ (5)	$\bar{r}$ [36] (6)	$\bar{R}^2$	J-test (7)	Wald Test [1]
Eq.(1) estimated over different sample periods										
1 GMM	1985:01–2002:02	1.80 (0.67)	0.87 (0.05)	1.93 (0.25)	0.28 (0.13)	(-)	3.20 (3.7)	0.99	0.024	1.93 (0.15)
29 GMM	1988:01–2002:02	0.75 (0.59)	0.91 (0.04)	2.20 (0.25)	0.33 (0.17)	(-)	2.55	0.99	0.046	4.43 (0.01)
30 GMM	1990:01–2002:02	0.17 (1.10)	0.96 (0.02)	1.89 (0.54)	0.57 (0.31)	(-)	1.51	0.99	0.059	0.83 (0.44)
31 GMM	1992:01–2002:02	0.89 (1.06)	0.95 (0.02)	1.59 (0.58)	0.55 (0.36)	(-)	1.78 (2.1)	0.99	0.074	0.03 (0.97)
32 GMM	1995:01–2002:02 [2]	2.19 (0.38)	0.90 (0.01)	1.02 (0.21)	0.01 (0.06)	(-)	2.22	0.97	0.152	46.70 (0.00)
33 GMM	1999:01–2002:02	2.60 (0.20)	0.72 (0.04)	0.45 (0.10)	0.30 (0.03)	(-)	1.78	0.97	0.148	145.5 (0.00)

Notes to Table 4:

The equations are estimated using the Generalised Method of Moments. When not specified otherwise, the instrument set includes lagged values (up to 6 lags) of inflation and the output gap. Industrial production is used to capture output developments on a monthly frequency, apart from the cases when the use of real GDP is explicitly mentioned.

[1] p-value, null hypothesis that the coefficients on the output gap and the inflation term are jointly not statistically different from 0.5 and 1.5, respectively.

[2] The instrument list includes: lagged values (1 up to 6 lags) of the monthly annualised inflation rate and the output gap; lagged values rate (2 up to 3) of the short-term interest rate, the monthly annualised changes in nominal M3 and the annual changes in commodity prices.

[36] The values of the equilibrium real interest rate reported in brackets refer to an inflation objective equal to 2%.

6. Sensitivity of the results using different sets of Instrumental Variables

As already mentioned in Section 4.2, the choice of the Instruments Variables (IV) set that we use in our main estimations, apart from being consistent with what is commonly used in the literature, can also be justified for reasons of parsimony. In fact, as the estimates in Table 5 below show, additional instruments easily tend to widen the standard errors of the coefficients thus making the tests more imprecise.

Table 5

Estimates of Taylor rules in the euro area – sample period 1985:01-2002:02

No. of eq.	Specification	α (1)	ρ (2)	β (3)	γ (4)	δ (5)	$\bar{r}$ (6)	$\bar{R}^2$	J-test (7)	Wald Test [1]
Different instrumental variables (IV)										
1 GMM	Simple Taylor rule	1.80 (0.67)	0.87 (0.05)	1.93 (0.25)	0.28 (0.13)	(-)	3.20	0.99	0.024	1.93 (0.15)
34 GMM	Simple Taylor rule [2]	0.96 (1.82)	0.98 (0.01)	1.97 (0.76)	1.00 (0.68)	(-)	2.42	0.99	0.098	0.94 (0.39)
35 GMM	Simple Taylor rule [3]	0.60 (0.98)	0.96 (0.01)	1.97 (0.43)	0.47 (0.19)	(-)	2.10	0.99	0.106	0.73 (0.48)
36 GMM	Simple Taylor rule [4]	0.33 (0.55)	0.94 (0.01)	2.16 (0.22)	0.37 (0.09)	(-)	2.07	0.99	0.143	4.51 (0.01)

Notes to Table 5:

The equations are estimated using the Generalised Method of Moments. When not specified otherwise, the instrument set includes lagged values (up to 6 lags) of inflation and the output gap. Industrial production is used to capture output developments on a monthly frequency, apart from the cases when the use of real GDP is explicitly mentioned.

[1] *p-value, null hypothesis that the coefficients on the output gap and the inflation term are jointly not statistically different from 0.5 and 1.5, respectively.*

[2] *The instrument set includes: lagged values (1 up to 6, 9 and 12 lags) of the monthly annualised inflation rate and the output gap; lagged values (2 up to 6, 9 and 12 lags) of the short-term interest rate and a constant.*

[3] *The instrument set includes: lagged values (1 up to 6, 9 and 12 lags) of the monthly annualised inflation rate, the output gap and monthly annualised changes in nominal M3; lagged values (2 up to 6, 9 and 12 lags) of the short-term interest rate and a constant.*

[4] *The instrument set includes: lagged values (1 up to 6, 9 and 12 lags) of the monthly annualised inflation rate, the output gap, monthly annualised changes in nominal M3 and in the nominal euro effective exchange rate; lagged values (2 up to 6, 9 and 12 lags) of the short-term interest rate, lagged values (2 up to 6) of the monthly annualised changes in commodity prices and a constant.*

7. Sensitivity of the estimates to different estimation techniques

We also cross-check the results of some selected reaction function specifications obtained with GMM with those estimated using the Ordinary Least Squares (OLS) and the Two Stage Least Squares (TSLS) estimation methods.

When considering OLS estimates (with the exception of eq.(37b)), the coefficient on the output gap seems to be upward biased whereas the coefficient on inflation seems to be downward biased compared to GMM estimates.

Conversely, it turns out that the TSLS coefficient estimates (based on the same set of IV used for the GMM method) resemble closely those obtained with the GMM method. This result can be interpreted as an indication of the relative superiority of the Instrumental Variables approach.

Table 6

Estimates of Taylor rules in the euro area – sample period 1985:01-2002:02

No. of eq.	Specification	α (1)	ρ (2)	β (3)	γ (4)	δ (5)	$\bar{r}$ (6)	$\bar{R}^2$	J-test (7)	Wald Test [1]
GMM, OLS and TSLS estimations										
1a GMM	Simple Taylor rule	1.80 (0.67)	0.87 (0.05)	1.93 (0.25)	0.28 (0.13)	(-)	3.20	0.99	0.024	1.93 (0.15)
1b OLS	"	2.41 (3.10)	0.98 (0.01)	1.03 (1.25)	1.78 (1.27)	(-)	2.46	0.99	(-)	0.54 (0.58)
1c TSLS	"	1.77 (0.59)	0.88 (0.04)	1.94 (0.23)	0.26 (0.12)	(-)	3.18	0.99	(-)	2.28 (0.10)
26a GMM	No lagged interest rate	1.61 (0.55)	(-)	2.08 (0.18)	0.06 (0.05)	(-)	3.23	0.67	0.031	66.2 (0.00)
26b OLS	"	1.88 (0.31)	(-)	1.97 (0.11)	0.06 (0.03)	(-)	3.34	0.66	(-)	82.5 (0.00)
26c TSLS	"	1.25 (0.34)	(-)	2.24 (0.12)	0.01 (0.04)	(-)	3.11	0.68	(-)	86.47 (0.00)
13a GMM	Money growth gap (b)	1.51 (0.69)	0.92 (0.03)	1.86 (030)	0.26 (0.18)	0.41 (0.17)	2.80	0.99	0.050	1.21 (0.30)
13b OLS	"	4.39 (5.31)	0.99 (0.01)	-0.01 (2.71)	2.18 (2.35)	0.28 (0.85)	2.92	0.99	(-)	0.25 (0.78)
13c TSLS	"	2.843 (2.16)	0.96 (0.03)	1.18 (1.05)	0.71 (0.73)	0.36 (0.29)	3.11	0.99	(-)	0.05 (0.95)
37a GMM	No lagged interest rate & money growth gap (b)	2.18 (0.53)	(-)	1.77 (0.21)	-0.02 (0.05)	0.40 (0.11)	3.34	0.74	0.068	52.90 (0.00)
37b OLS	"	1.34 (0.31)	(-)	2.04 (0.13)	-0.10 (0.03)	0.42 (0.06)	2.90	0.75	(-)	149.90 (0.00)
37c TSLS	"	1.07 (0.33)	(-)	2.15 (0.13)	-0.10 (0.04)	0.40 (0.06)	2.80	0.76	(-)	132.49 (0.00)
5a GMM	HP-filter on real GDP [2]	1.18 (0.54)	0.84 (0.06)	2.16 (0.20)	0.53 (0.64)	(-)	2.92	0.98	0.019	11.1 (0.00)
5b OLS	"	0.48 (4.61)	0.99 (0.01)	1.54 (1.60)	7.89 (8.99)	(-)	1.29	0.99	(-)	0.40 (0.67)
5c TSLS	"	1.40 (0.58)	0.89 (0.04)	2.11 (0.21)	0.73 (0.64)	(-)	3.07	0.99	(-)	5.70 (0.00)

Notes to Table 6:

The equations are estimated using the Generalised Method of Moments. When not specified otherwise, the instrument set includes lagged values (up to 6 lags) of inflation and the output gap. Industrial production is used to capture output developments on a monthly frequency, apart from the cases when the use of real GDP is explicitly mentioned.

[1] p-value, null hypothesis that the coefficients on the output gap and the inflation term are jointly not statistically different from 0.5 and 1.5, respectively.

[2] When potential output is computed using the Hodrick-Prescott filter, the smoothing parameter is set equal to 14400 for monthly data and 1600 for quarterly data.

8. Sensitivity of the results to selected Taylor rule variants

Table 7 contains a comparison of some variants of the Taylor rule. Besides the inclusion of the deviation of inflation from its estimated objective (see eq.(22a)), these variants also include, as additional explanatory variables, either (a) the money growth gap (b) indicator (see eq.(22b)) or (b) the changes in real asset prices corrected for economic activity growth (see eq.(22c)). Both additional explanatory variables turn out to exhibit the expected sign and to be statistically different from zero. However, in the last specification, all coefficient estimates vary substantially with respect to those of the baseline equation (see eq.(1)).

Table 7

Estimates of Taylor rules in the euro area – sample period 1985:01-2002:02

No. of eq.	Specification	α (1)	ρ (2)	β (3)	γ (4)	δ (5)	$\bar{r}$ (6)	$\bar{R}^2$	J-test (7)	Wald Test [1]
Variants of eq.(22)										
22a GMM	Deviation of infl. from its target	5.50 (0.48)	0.93 (0.04)	1.91 (0.45)	0.38 (0.24)	(-)	4.00	0.99	0.029	0.41 (0.66)
22b GMM	Deviation of infl. from its target & money growth gap (b)	4.91 (0.44)	0.94 (0.03)	1.56 (0.50)	0.30 (0.23)	0.75 (0.23)	3.41	0.99	0.049	0.40 (0.67)
22c GMM	Deviation of infl. from its target & DJ real Euro Stoxx 50 corrected for ind. prod. growth	2.21 (1.20)	0.97 (0.02)	2.65 (0.56)	0.72 (0.45)	0.08 (0.04)	0.71	0.99	0.065	3.21 (0.04)

Notes to Table 7:

The equations are estimated using the Generalised Method of Moments. When not specified otherwise, the instrument set includes lagged values (up to 6 lags) of inflation and the output gap. Industrial production is used to capture output developments on a monthly frequency, apart from the cases when the use of real GDP is explicitly mentioned.

[1] *p-value, null hypothesis that the coefficients on the output gap and the inflation term are jointly not statistically different from 0.5 and 1.5, respectively.*

Table 8 presents the results derived from a similar type of exercise using the specification of the Taylor rule which includes the money growth gap (b) indicator (see eq.(13a)). In this respect, we consider two variants: the first one omits the smoothing term, whereas the second one contains the additional explanatory variable represented by the real DJ Euro Stoxx 50 corrected for economic growth. Independently of the inclusion of the smoothing of the interest rate, the coefficient of the output gap is not statistically different from zero. The opposite result holds for the specification in eq.(38) where the output gap and asset prices enter significantly into the equation whereas the money growth gap indicator is not found to be of relevance any longer.[37]

Table 8

Estimates of Taylor rules in the euro area – sample period 1985:01-2002:02

No. of eq.	Specification	α (1)	ρ (2)	β (3)	γ (4)	δ (5)	λ	$\bar{r}$ (6)	$\bar{R}^2$	J-test (7)	Wald Test [1]
Variants of eq.(13)											
13a GMM	Money growth gap (b)	1.51 (0.69)	0.92 (0.03)	1.86 (0.30)	0.26 (0.18)	0.41 (0.17)	(-)	2.80	0.99	0.050	1.21 (0.30)
37 GMM	No lagged interest rate & money growth gap (b)	2.18 (0.53)	(-)	1.77 (0.21)	-0.02 (0.05)	0.40 (0.11)	(-)	3.342	0.74	0.068	53.00 (0.00)
38 GMM	Money growth gap (b) & real DJ Euro Stoxx 50 corrected for ind. prod. growth	-1.24 (0.97)	0.95 (0.02)	2.36 (0.40)	0.55 (0.25)	-0.07 (0.24)	0.06 (0.03)	0.80	0.99	0.072	2.77 (0.07)

Notes to Table 8:

The equations are estimated using the Generalised Method of Moments. When not specified otherwise, the instrument set includes lagged values (up to 6 lags) of inflation and the output gap. Industrial production is used to capture output developments on a monthly frequency, apart from the cases when the use of real GDP is explicitly mentioned.

[1] *p-value, null hypothesis that the coefficients on the output gap and the inflation term are jointly not statistically different from 0.5 and 1.5, respectively.*

4.4 The equilibrium real interest rate

As already mentioned in the assessment of the results presented in Table 4, the implicit equilibrium real interest rate has experienced a downward trend over time. A possible explanation of the fact that the equilibrium real interest rate implied by the Taylor rule could have been higher in the 80s and early 90s than at present is the fact that the most recent period was one of disinflation and significant fiscal consolidation, together with increasing credibility of the convergence process.

We carry out a further investigation of the behaviour of the implicit equilibrium real interest rate by considering the following two different approaches, both based on a time-varying inflation objective.

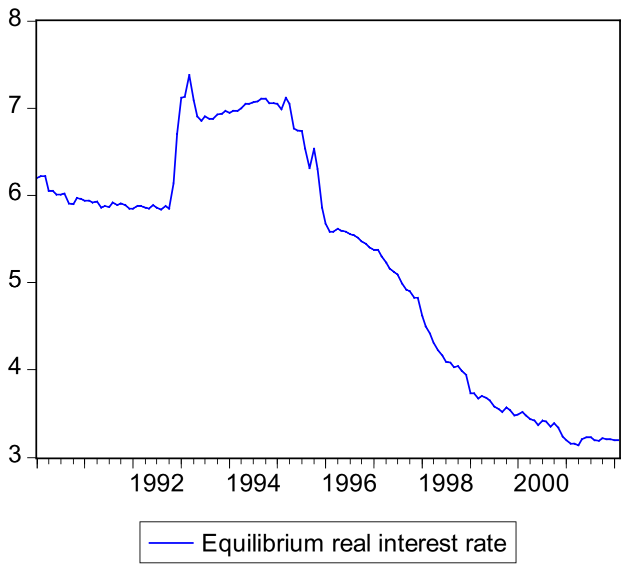
[37] A possible explanation for this result may be represented by the fact that asset prices might be, at least in certain periods, a relevant explanatory variable of money demand. Therefore, when introduced together with M3 in the set of the right-hand side variables in the policy reaction function, a problem of multicollinearity might arise thus impacting on the significance of the coefficients. This topic is, however, left for future research.

In the first approach, we derive the value of this variable recursively using the (time-varying) euro area inflation objective described in Annex B, assuming that, during the convergence process, this inflation objective in each recursively selected sample period coincided with its latest observation in the same selected sample period.[38] Figure 5 below shows that some local peaks were present around the early 90s but, subsequently, the implicit equilibrium real interest rate exhibits a steep decline from 1996 onwards.

Figure 5

Recursive estimates of the equilibrium real interest rate in the euro area

Percentage points per annum



In our second approach, we derive the equilibrium real interest rate using a Kalman filter framework (see Annex D for further detail). In particular, it is assumed that, in the baseline specification of the Taylor rule (see eq.(1)), the constant (out of which the equilibrium real interest rate is derived) follows an autoregressive process of order one (i.e. it is an AR(1) process) while the other coefficients are assumed to be constant.[39] In order to derive the equilibrium real interest rate, the time-varying inflation objective is used. In this case, the equilibrium real interest rate looks a bit more volatile. Nevertheless, from 1996 onwards, this procedure also shows a pronounced decline in the equilibrium real interest rate which reached a value of around 1% at the end of the sample.

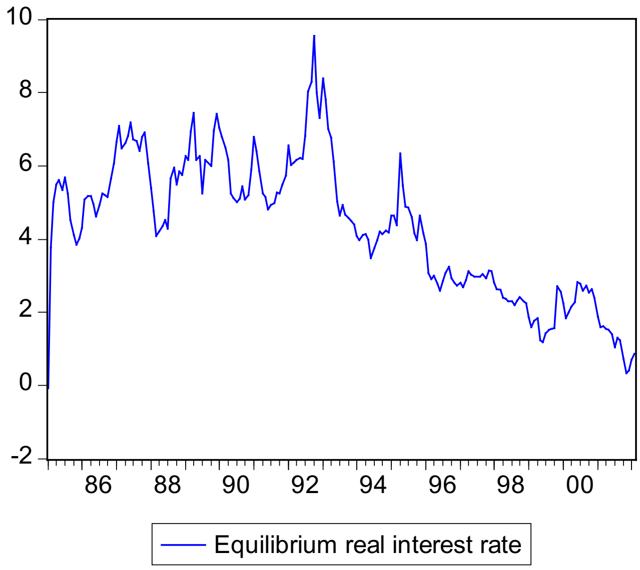
38 In this exercise we use the baseline specification (see Table 1, eq.(1)).

39 There are good reasons to assume that the behaviour of the real interest rate follows a random walk. In this respect, our specification is more encompassing in that it allows for parameter values different from one. The resulting coefficient, however, is 0.99 with a standard error of 0.01, thus basically confirming the random walk hypothesis.

Figure 6

Time-varying estimate of the euro area equilibrium real interest rate

Percentage points per annum



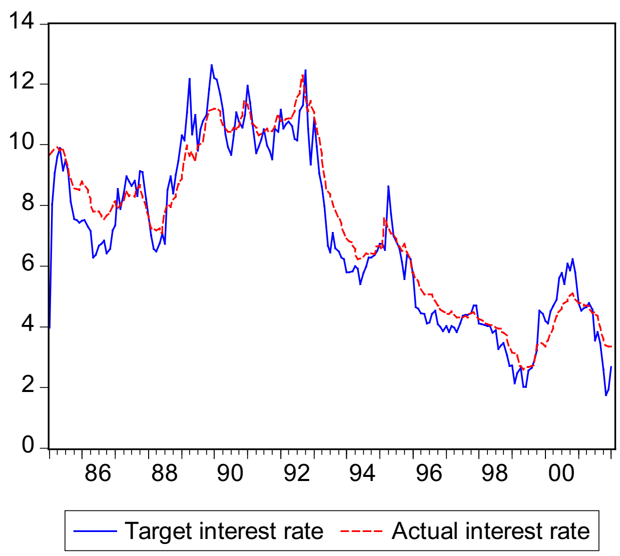
It turns out that the target interest rate derived from the Taylor rule specification estimated using the Kalman filter seems to track quite well the pattern of the short-term interest rate (see figure below).[40]

[40] This result holds also when a backward-looking specification is adopted.

Figure 7

Actual and target interest rates implied by the Taylor rule (baseline specification, eq.(1))

Percentage points per annum



5. Conclusions

This paper has investigated the impact of a number of variables on the decisions of a fictitious central bank in the euro area in its setting of the policy interest rate over the last two decades. The exercise has also considered a number of other issues, such as a robustness check of the basic results with respect to various sources of data and model uncertainty. The following conclusions can be drawn.

First, Taylor-like rules estimated over the last two decades appear to be able to capture on average, from an *ex-post* perspective, substantial elements of past monetary policy behaviour of a fictitious central bank in the euro area especially when a smoothing term (i.e. a lagged interest rate) is included. The estimated (long-run) coefficients for the main variables often do not differ (in statistical terms) from those originally suggested by Taylor (1.5 and 0.5 for inflation and the output gap, respectively). In particular, considering the simple version of the Taylor rule with smoothing, the response coefficient to inflation would imply that an increase in the inflation rate of one percentage point is associated with 190-220 basis points higher short-term nominal interest rate. The coefficient on the output gap instead is slightly affected by the measure employed for real activity. When using industrial production instead of GDP, the estimated responses of the interest rate to this variable is lower. Overall, the range of the response of the interest rate to a change in the output gap of one percentage point would vary between 13 and 50 basis points.

Second, the coefficient on the lagged interest rate appears to be very stable and significant across all the specifications, ranging between 0.8 and 0.9. This result could be well explained on both statistical and economic grounds; however, it may be worth further investigation.

Third, the deviation of M3 growth from its reference value (also interpretable as a money growth gap indicator) enters significantly the list of determinants. Moreover, it slightly reduces both the coefficient of the output gap and the one of inflation. A possible interpretation could be that, over that sample period, excess money growth contained information for monetary policy makers which was not (fully) included either in the inflation term or the output gap. In relation to this, in the case of a Taylor rule specification including money among the right-hand side variables, the issue of "observational equivalence" should be noted. Given the fact that nominal money and nominal income (as well as real money and real income) are highly correlated, it might well be that the estimation procedure tends to mix the effects of these two variables. Still, given that monetary data become available earlier than nominal GDP data and are usually subject to smaller revisions, it may be rational for central banks to focus on the former in the real-time policy process.

Finally, the implied estimate of the equilibrium real interest rate is around or above 3% when estimating since the early 80s, but it tends to decline when data for the most recent period (the 90s) are used.

This notwithstanding, the following caveats need to be kept in mind. First, these investigations are of an *ex-post* nature. Therefore, Taylor rules might be able to describe to some degree *ex-post* monetary policy of central banks which have been successful in stabilising inflation (and thereby output), independently of the actual strategies and policies followed by the same central banks. Second, our results refer to a fictitious central bank given that the ECB was only officially responsible for the conduct of monetary policy in the euro area with the start of Stage Three of EMU. In this respect, prior to 1999 the outcome reflects the "average" monetary policy of the national central banks in the countries currently forming the EMU. Therefore, our results should not be overemphasised given the fact that the Deutsche Bundesbank, when deciding on the course of monetary policy, assigned a high weight to developments in monetary aggregates while the monetary policy of many European central banks was constrained by the ERM.

Third, the estimation of these rules does not take into account that the information on some variables is not available in real time whereas central banks are constrained to operate in real time. The data used are thus sometimes incomplete and often subject to substantial revisions. This might apply to the inflation forecasts as well as to measures for the output gap. This important extension, that might bear far-reaching implications, is left for future research.

Fourth, there is substantial uncertainty around the parameters estimates which turn out to be rather sensitive to the specification of the rule (e.g. forward-looking versus backward-looking), the measure and the construction of the variables included in the rule and the sample period considered for the estimation.

Fifth, it is a well-documented fact in the recent literature that Taylor rules leave the real economy without an anchor. As shown by a number of authors, Taylor rules can themselves be a source of real economic instability.[41] This issue has, of course, not been dealt with in this investigation.

Finally, the high degree of inertia or smoothing in the policy interest rate might reflect a deliberate smoothing objective of the central bank or a possible misspecification of the model (pointing, for instance, to omitted variables which are autocorrelated or to serially correlated shocks), thus leaving room for future research.

[41] These pathologies can even occur when a stabilising Taylor rule (i.e. a rule characterised by an inflation response higher than unity) is followed. Christiano and Rostagno (2001) have shown that a monetary monitoring (i.e. a policy that includes a commitment to switch to a money growth target in the event that the economy slips into deflation) might be helpful in such a case.

REFERENCES

Alesina, A.F., O.J. Blanchard, J. Galí, F. Giavazzi and H. Uhlig (2001), "Defining a macroeconomic framework for the euro area – No. 3", *CEPR,* London

Bernanke, B. and I. Mihov (1995), "Measuring monetary policy", *NBER Working Paper*, No. 5145

Brand, C., D. Gerdesmeier and B. Roffia (2002), "Estimating the M3 income velocity underlying the reference value for monetary growth", *ECB Occasional Paper*, No. 3

Brown, R.L., J. Durbin and J.M. Evans (1975), "Techniques for testing the constancy of regression relationships over time", *Journal of the Royal Statistical Society*, Series B, Vol. 37, pp. 149-192

Calza, A., D. Gerdesmeier and J. Levy (2001), "Euro area money demand: measuring the opportunity costs appropriately", *IMF Working Paper*, No. 01/179

Chow, G. and A. Lin (1971), "Best linear unbiased interpolation, distribution and extrapolation of time series by related series", *The Review of Economic and Statistics*, Vol. 53, No.4, pp. 372-375

Christiano, L.R. and M. Rostagno (2001), "Money growth monitoring and the Taylor rule", *NBER Working Paper,* No. 8539

Clarida, R., J. Galí and M. Gertler (1998), "Monetary policy rules in practice. Some international evidence", *European Economic Review*, Vol. 42, pp. 1033-1067

Deutsche Bundesbank Monthly Report "Taylor interest rate and Monetary Conditions Index", April 1999

ECB (1998), "The Quantitative Reference Value for Monetary Growth", Press Release, 1 December 1998

ECB (2001), "Issues related to monetary policy rules", *ECB Monthly Bulletin*, October 2001

Faust, J, J.H. Rogers and J.H. Wright (2001), "An empirical comparison of Bundesbank and ECB monetary policy rules", *Board of Governors of the Federal Reserve System, International Finance Discussion Papers*, No. 705

Favero, C. A. (2001), Applied Macroeconometrics, Oxford University Press

Galí, J. (2001), "Monetary policy in the early years of EMU", *Pompeu Fabra University,* mimeo

Gerlach, S. and G. Schnabel (1999), "The Taylor rule and interest rates in the EMU area: a note", *BIS Working Paper*, No. 73

Gerlach, S and L.E.O. Svensson (2001), "Money and inflation in the euro area: a case for monetary indicators?", *Bank for International Settlement Working Paper*, No. 98

Granger, C.W.J. (1986), "Developments in the study of cointegrated economic variables"*, Oxford Bulletin of Economics and Statistics,* Vol. 48, pp. 213-228

Hamilton, J.D. (1994), “Time series analysis”, Princeton University Press

Hansen, L. (1982), "Large sample properties of generalised method of moments estimators", *Econometrica*, Vol. 50, pp. 1029-1054

Harvey, A. (1990), “Forecasting, structural time series models and the Kalman filter”, Cambridge University Press.

Johnston, J. and J. DiNardo (1997), "Econometric methods", McGraw-Hill, 4th ed.

Judd, J.P. and G.D. Rudebusch (1998), “Taylor’s rule and the Fed: 1970-1997”, *Federal Reserve Bank if San Francisco Economic Review*, No. 3, pp. 3-16

Newey, W. and K. West (1987) "A simple, positive definite, heteroskedasticity and autocorrelation consistent covariance matrix", *Econometrica*, Vol. 55, No. 3, pp. 703-708

Orphanides, A., (1998), “Monetary Policy Evaluation with Noisy Information”, *Finance and Economics Discussion Series Working Paper*, No. 1998-50, Board of Governors of the Federal Reserve System

Orphanides, A. (2001), "Monetary policy rules based on real-time data", *The American Economic Revew,* Vol. 91, No. 4, pp. 964-985

Orphanides, A. and van Norden, S. (2001), “The unreliability of output gap estimates in real time”, *CIRANO Working Papers*

Peersman, G. and F. Smets (1998), “Uncertainty and the Taylor rule in a simple model of the euro area economy”, mimeo

Rudebusch, G. (2002), "Term structure evidence on interest-rate smoothing and monetary policy inertia", Vol. 49, pp. 1161-1187

Taylor, J.B. (1993), “Discretion versus policy rules in practice”, *Carnegie-Rochester Conference Series on Public Policy*, Vol. 39, pp. 195-214

Woodford, M. (1999), “Optimal Monetary Policy Inertia”, *NBER Working Paper*, No. 7261

ANNEX A. DESCRIPTION OF THE DATA

The historical series used in this study generally span the sample January 1985 - February 2002 and refer to the euro area (i.e. the euro area-11 for months up to December 2000, and the euro area-12 from January 2001 onwards). The quarterly data are compiled as averages of the monthly data.

Monetary aggregates

M3 is constructed using the data on seasonally adjusted month-end stocks and flows. The series is constructed as follows. The seasonally adjusted index of adjusted stocks is rebased to be equal to 100 in January 2001 and then multiplied by the seasonally adjusted stock in January 2001. The percentage change between any two dates (after October 1997) corresponds to the change in the stock excluding the effect of reclassifications, other revaluations and exchange rate variations (and from January 2001 excluding the effect of the enlargement).

Interest rates

The euro area interest rates are a weighted average of national interest rates calculated with fixed weights based on 1999 GDP at PPP exchange rates. Short-term interest rates are three-month money market rates. From January 1999 onwards, the three-month EURIBOR is used. Long-term interest rates correspond to ten-year government bond yields, or the closest available maturity.

For the compilation of the own rate of return on M3, see Calza, Gerdesmeier and Levy (2001). As explained in that paper, this rate is computed by splicing two separate measures of the rate: (1) the estimated aggregate own rate of M3 in the largest euro area countries between January 1980 and December 1989; and (2) the own rate of M3 in the euro area as a whole from January 1990 onwards (*cf.* Calza, Gerdesmeier and Levy (2001), p. 19).

The overnight interest rate for the United States is represented by the money market rate, Federal Funds Rate, and is taken from the BIS database.

GDP and industrial production

The seasonally adjusted nominal GDP series – on a quarterly frequency – is constructed as follows: a) by aggregating national GDP data using the irrevocable fixed exchange rates of 31 December 1998[42] for the period 1980 Q1-1998 Q4; b) using, from 1999 Q1 onwards, the official Eurostat series;[43] c) by compiling an "artificial" series which, from 2000 Q4 onwards, covers the euro-12 series, whereas the observations from 2000 Q4 backwards are extrapolations based on growth rates calculated from the series compiled in points (a) and (b) above.[44]

The seasonally adjusted real GDP series (at market prices, constant prices taken 1995 as the base year), on a quarterly frequency, is constructed by following these steps: a) by aggregating national GDP data using the irrevocable fixed exchange rates of 31 December 1998 for the period 1980 Q1-1998 Q4; b) by re-scaling the series obtained so that it is consistent with the nominal GDP series in 1995; c) by compiling an "artificial" series which, from 2000 Q4 onwards, covers the euro-12 series, whereas the observations from 2000 Q4 backwards are extrapolations based on growth rates calculated from the series compiled in points (a) and (b) above.

The GDP deflator is calculated as a simple ratio between nominal and real GDP. Annex B describes the method used to convert nominal and real GDP from quarterly into monthly frequency.

The Industrial Production Index refers to total Industry (excluding construction), Eurostat source. The index is working day and seasonally adjusted, and the unit index base is 1995 = 100.

Price indices

The HICP index for the euro area is the seasonally adjusted overall based on consumption expenditure weights at irrevocable fixed exchange rates of 31 December 1998. Data before January 1995 are compiled from monthly rates of change of national CPIs excluding owner occupied housing (except for Spain). The seasonal adjustment methodology is described in the Technical Notes contained in the "Euro area Statistics" section of the ECB Monthly Bulletin. The HICP all-items index excluding energy and unprocessed food prices (which is available only from January 1991 onwards) is also used. The series for oil prices – world-market prices, energy raw material, crude oil – is taken from the BIS database and converted into euro using the BIS exchange rate series of the euro vis-à-vis the US dollar. Commodity prices are represented by world market prices of raw materials (total index) converted into euro. The weighting scheme is based on commodity imports of OECD countries, 1989-1991, excluding EU-internal trade. The Dow Jones (i.e. DJ) Euro Stoxx 50 Blue Chip Index consists of 50 stocks covering the market sector leaders in the DJ Euro Stoxx index. The series is on euro basis

[42] For compiling the euro-12 series, the irrevocable fixed exchange rate for Greece determined on 19 June 2000 is used.

[43] Obviously, the series in point (a) is re-scaled to match the Eurostat series in 1999 Q1.

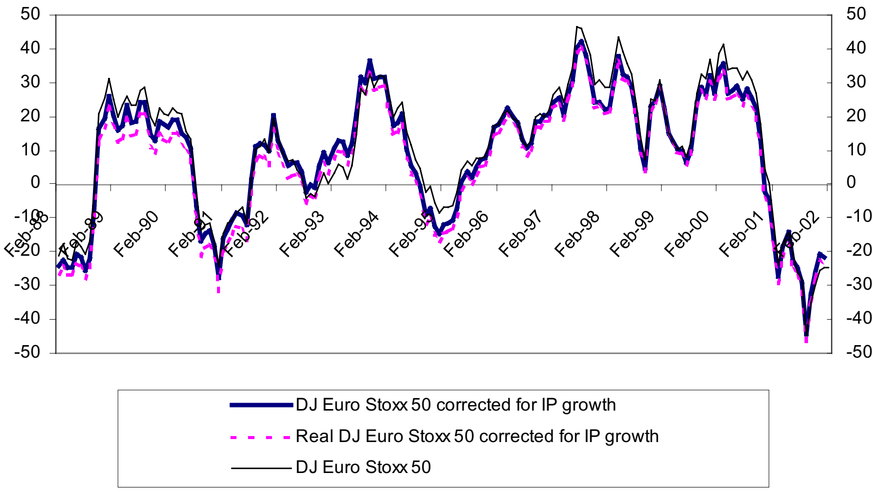
[44] See Brand, Gerdesmeier and Roffia (2002).

(historical values of indices are calculated with historical daily exchange rates). The series of the DJ Euro Stoxx 50, both in nominal and real terms, corrected for the IP growth are showed in the table below.

Figure 8

Euro Stoxx 50 indicators

Annual percentage change



Exchange rates

The nominal US dollar/euro (i.e. US $/euro) exchange rate is taken from the BIS and represents the exchange rate US dollar/1EUR(ECU), spot at 2.15 PM (CET) M-average. The corresponding real exchange rate is derived from the nominal exchange rate deflated by the HICP index.

The nominal effective exchange rate of the euro vis-à-vis 25 countries (21 industrialised countries and 4 Asian countries) is also taken from the BIS. The calculation is based on weights derived from merchandise trade flows in manufactured goods excluding the trade between countries participating in the monetary union (intra EU-11 trade). The real effective exchange rate of the euro is deflated by the CPI index. Both these two exchange rate series are extended from 1999 onwards using the changes in the effective exchange rate of the euro vis-à-vis the narrow group from the ECB databank.

ANNEX B. CALCULATION OF POTENTIAL OUTPUT, MONTHLY GDP, REFERENCE VALUE FOR M3 GROWTH AND INFLATION OBJECTIVE

Potential output

A measure of potential output is derived for both industrial production and real GDP using three different methods which are applied to both economic variables in the same way.

These methods are the following:

- ***Linear trend***

This method consists in fitting a linear trend to the data. This method assumes that the trend in output is well approximated as a simple deterministic function of time.

- ***Quadratic trend***

This method consists in fitting a quadratic trend to the data. It assumes that the trend in output (or industrial production) is approximated by a simple exponential function of time. The output gap is then computed as the deviation of output from its potential level.

- ***HP Filter***

This is a smoothing method that is widely used among macroeconomists to obtain a smooth estimate of the long-term trend component of a series. The method was first used in a working paper (circulated in the early 1980s and published in 1997) by Hodrick and Prescott to analyse postwar U.S. business cycles. Technically, the Hodrick-Prescott (HP) filter is a two-sided linear filter that computes the smoothed series s of y by minimising the variance of y around s, subject to a penalty that constrains the second difference of s. That is, the HP filter chooses s to minimise:

$$\sum_{t=1}^{T}(y_t - s_t)^2 + \lambda\sum_{t=2}^{T-1}((s_{t+1} - s_t) - (s_t - s_{t-1}))^2 .$$

The penalty parameter λ controls the smoothness of the series σ. The larger the λ, the smoother the σ. As $\lambda \to \infty$, s approaches a linear trend.

Monthly GDP

The quarterly GDP series are converted into monthly using the Chow and Lin (1971) procedure. The idea is that the GDP is observable at the quarterly frequency but the indicators used to disaggregate it are observable at a highest frequency, i.e. are available on a monthly basis, and are potentially informative variables. The indicators which are used are industrial production excluding construction, new car registrations, industrial production in construction, real retail sales indicators and industrial production in construction indicator, all series referring to historical euro-12. The formula applied has the property that, in each quarter, the average of monthly computed values of GDP equals the actual quarterly value.[45]

Inflation Objective

The inflation objective for the euro area is modelled using a slightly adjusted version of the method followed by Gerlach and Svensson (2001). The two authors assumed that prior to 1999 the long-run inflation objective of the central banks in the countries which later formed the euro area was, over the last two decades, to reduce inflation to the level given by the Bundesbank's normative inflation objective (see Figure 9 below).[46] In mathematical terms, this can be expressed by the following formula:

$$\hat{\pi}_{t+1} - \hat{\pi}^{b}_{t+1} = \gamma(\hat{\pi}_{t} - \hat{\pi}^{b}_{t})$$

where $\hat{\pi}^{b}_{t}$ denotes the Bundesbank's inflation objective and γ the rate of convergence of the (unknown) inflation objective $\hat{\pi}_{t}$ towards the (known) Bundesbank's objective.[47] By iterating backwards, eq.(5) can be also written as follows: [48]

$$\hat{\pi}_{t+1} - \hat{\pi}^{b}_{t+1} = \gamma^{t+1-t_0}(\hat{\pi}_{t_0} - \hat{\pi}^{b}_{t_0}) \text{ ,}$$

which implies that the gap between the two inflation objectives is related to their initial divergence at the time the process of convergence started (t_0 being assumed to be 1981 Q1). The inflation objective is assumed to be at the level of 1.5% from January 1999 onwards. In Gerlach and Svensson's paper, the parameter γ was estimated to be around 0.95, which implies a half-life of 3.4 years. This value for the coefficient γ is used in this paper. Figure 10 below illustrates the inflation objective for the euro area over the last two decades.

45 For a detailed explanation of the Chow and Lin procedure, see Bernanke and Mihov (1995).

46 This objective was referred to by the Bundesbank as "unavoidable inflation" or "price norm" or "a medium-term price assumption".

47 The rate of convergence is estimated within the inflation objective equation in the same paper. The euro area inflation objective is assumed to have a hyperbolic form. At the time the process of convergence started, the gap between the two objectives is quite huge (it is estimated to be around 6 percentage points), while it gradually shrinks to reach a negligible value in the beginning of 1999. Of course, this method to estimate the implicit inflation objective of euro area monetary authorities is rather ad hoc and may, in certain periods, be rather misleading. In our calculation, we assume that the inflation objective coincides with actual inflation at the starting point.

48 The original specification of the equation was based on quarterly data.

Figure 9

The Bundesbank's inflation objective

Annual percentage change

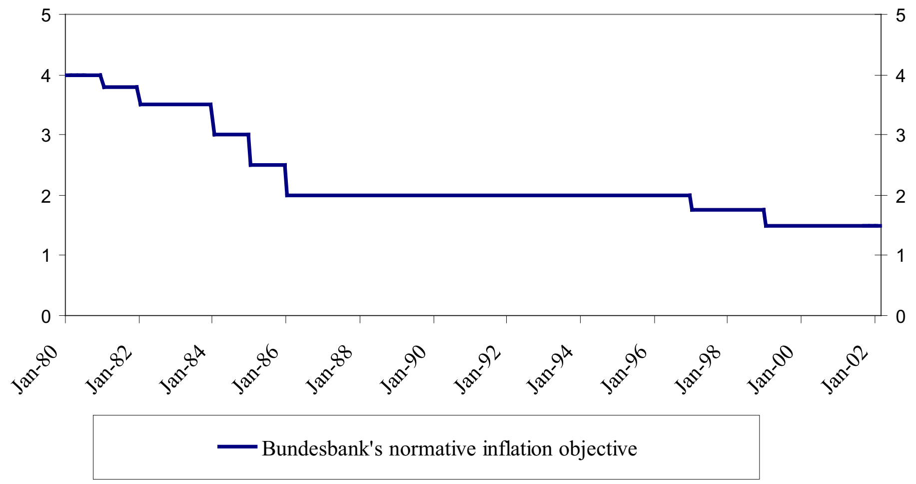
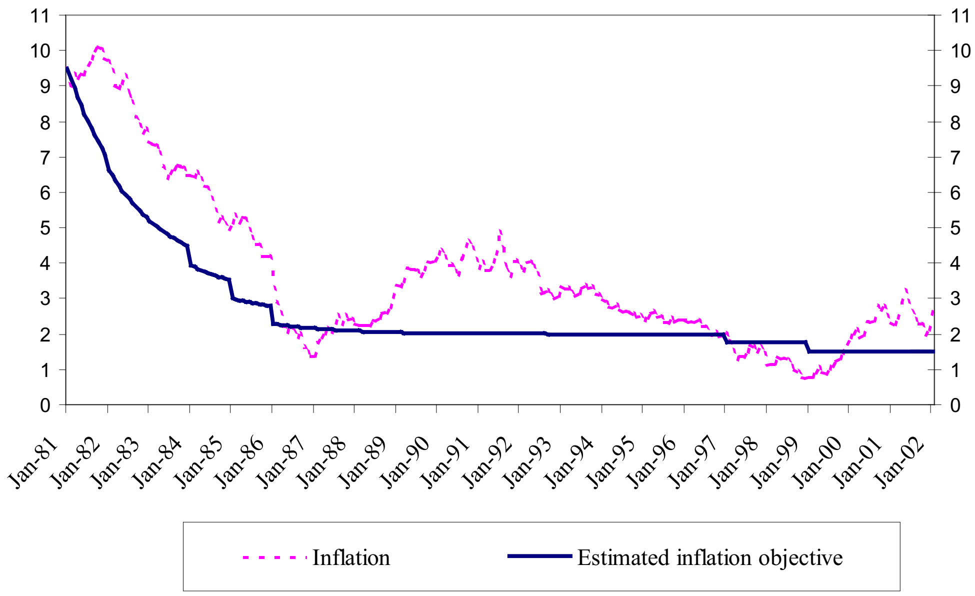


Figure 10

Actual inflation and the inflation objective in the euro area

Annual percentage change



Reference value for M3 growth

Two measures of the reference value for M3 growth are used to derive the money growth gap indicator.

The first measure of the reference value consists of a constant growth rate of 4½% per annum consistent with the reference value for monetary growth announced by the ECB's Governing Council in 1998. The derivation of the reference value is based on the standard relationship between money, real income, inflation, and the income velocity of circulation of money. The value of 4½% is based on the ECB's definition of price stability, i.e. an annual increase in the HICP for the euro area of below 2%, the assumption regarding the trend in potential output growth in the range of 2% to 2½% per annum and the assumption on the medium-term trend in M3 income velocity – a decline between ½% and 1% per annum.

The second measure is derived using the same standard relationship between money, real income, prices and the velocity of circulation of money, but using a different measure of the equilibrium values of these variables. With regard to prices, the data referring to the ECB's definition of price stability just described above are used. For the trend in potential output growth, the realised growth rates of the potential output series derived from the fit of the quadratic trend of industrial production are used. Finally, in order to calculate the medium-term trend of the velocity of circulation of money ($\Delta\overline{v}$), we apply the following formula:[49]

$$\Delta\overline{v}_t = (1-\beta)\Delta\overline{y}_t$$

where β represents the estimated long-run income elasticity from the money demand function considered and $\Delta\overline{y}$ is the trend in potential output. In this specific case, the coefficient β is derived from the estimation of the long-run money demand specified as suggested in Calza, Gerdesmeier and Levy (2001).[50]

The money growth gap indicator derived with the second method is pictured in the figure below.

---

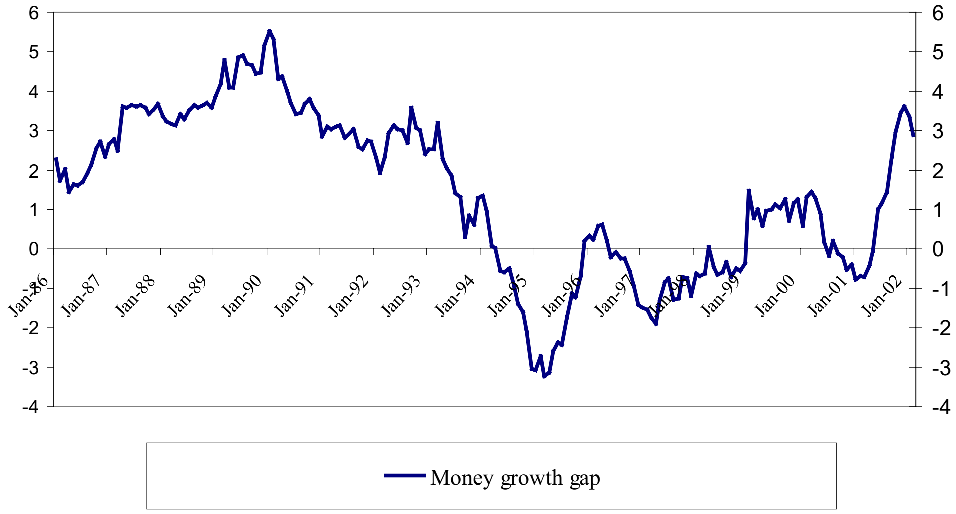
49 The formula assumes that the long-run equilibrium for the spread in the long-run money demand is constant.

50 However, from 1 January 1999 onwards, a value of 4½% is assumed for the reference value.

Figure 11

Money growth gap indicator

Annual percentage change



ANNEX C. PARAMETER CONSTANCY TESTS

This annex provides the results of some stability and specification tests for selected monetary policy reaction functions. In this respect, we focus on the widely known *Cusum* and *Cusum of Squares* tests.

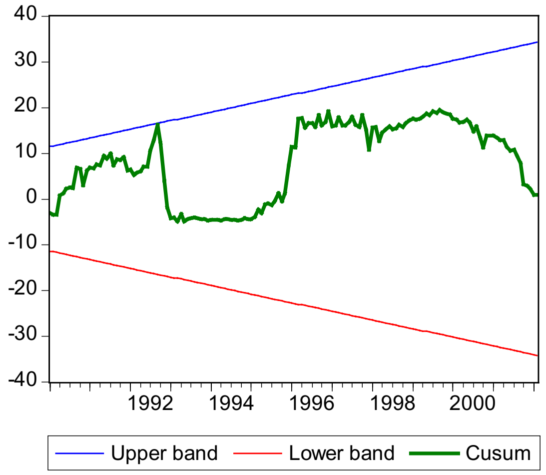
The Cusum test is based on the cumulative sum of the scaled recursive residuals. In the left-hand column of the charts below we plot the cumulated sum together with the 5% critical lines. The test would indicate parameter instability if the cumulative sum goes outside the area between the two critical lines.

The Cusum of Squares is based on the cumulative sums of squared residuals. Again, the significance of departures from the expected values can be assessed by movements outside the critical lines (see the right-hand column of the charts below). In order to allow for enough observations to estimate the reaction functions at the beginning of the sample, we run the tests from 1990 onwards.

Figure 12

Specification and diagnostics tests - baseline specification, eq.(1)

Cusum



Cusum of Squares

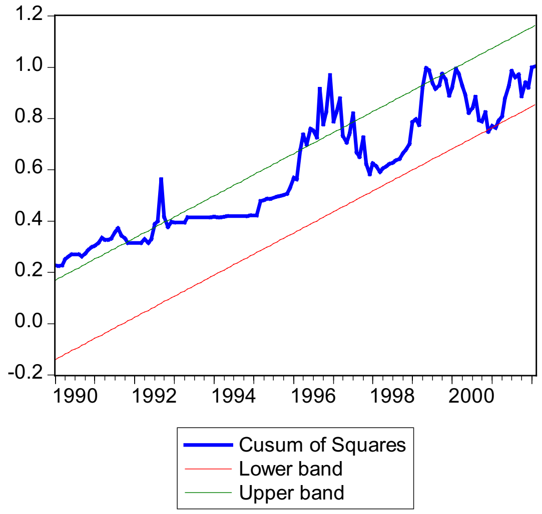


Figure 13

Specification and diagnostics tests - baseline specification without lagged interest rate, eq.(26)

Cusum ***Cusum of Squares***

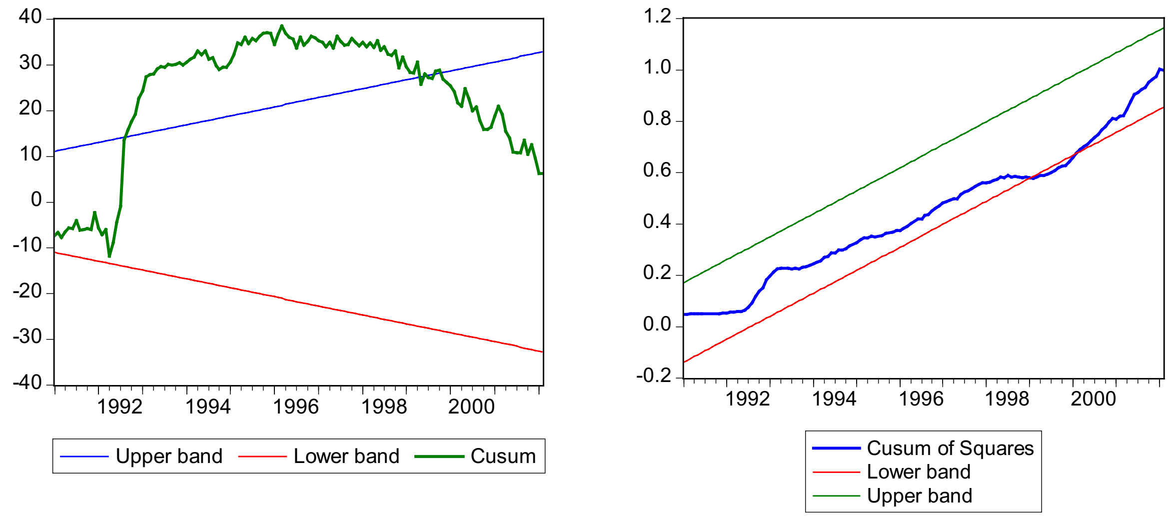
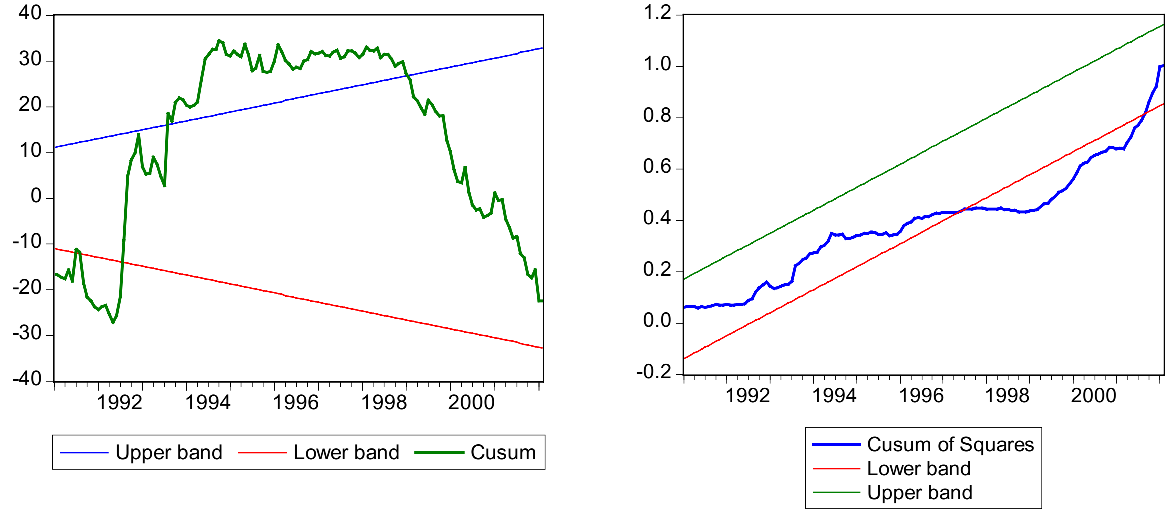


Figure 14

Specification and diagnostics tests - baseline specification with the money growth gap (b) indicator and no lagged interest rate, eq.(37a)

Cusum ***Cusum of Squares***



ANNEX D. A STOCHASTIC COEFFICIENT APPROACH TO MODELLING A SIMPLE TAYLOR RULE FOR THE EURO AREA

This annex focuses on the relaxation of the constant coefficient hypothesis applied in Section 4.4. It can be thus characterised as "moderately adaptive" as against models of "no adaptivity" (i.e. fixed parameter models).[51] Following the literature, the general model can be expressed in the following equations:

(D.1) $i_t = H'_t \vartheta_t + \xi_t$

(D.2) $\vartheta_t = T\vartheta_{t-1} + \eta_t$

(D.3) $\xi_t \sim \mathrm{N}(0, \sigma^2)$, $\eta_t \sim \mathrm{N}(0,\mathrm{Q})$ and $\vartheta_0 \sim \mathrm{N}(\mathrm{a}_0, \Sigma_0)$,

where H_t contains all the explanatory variables.

Equation (D.1) (the so-called *measurement equation*) is similar to the classical regression model except that the parameter vector ϑ (i.e. the state variable) is allowed to vary over time according to equation (D.2) (the so-called *transition equation*), which – in our case – is a first order autoregressive model for the state vector. The last equation describes the properties of the errors of measurement and transition equations, which are, furthermore, mutually and serially uncorrelated.

Finally, the framework used above includes the initial conditions for the state vector (i.e. the *a priori* distribution). In our application, it is assumed that T denotes an autoregressive process and thus evolves over time. Furthermore, a matrix Q is specified, the elements of which are estimated (using the maximum likelihood method) together with the rest of the parameters of the model.[52]

The *Kalman Filter algorithm* provides *a posteriori* estimates of the vector ϑ_t by means of expression for the expectation of this vector constrained by the information variable up to the period t, Ω_t, and the hyperparameter vector $\omega_0 = (a_0, \Sigma_0)$. This conditional mean provides an estimator for ϑ_t, in that it minimises the mean square error.[53]

51 See Granger (1986) for more details on this kind of issue.

52 For a more detailed discussion of the state space-modelling framework in econometrics, see Hamilton (1994).

53 See Harvey (1989) for a more technical description of the properties of the Kalman filter.

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