USING TAYLOR RULES TO UNDERSTAND ECB MONETARY POLICY

STEPHAN SAUER
JAN-EGBERT STURM

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Abstract

Over the last decade, the simple instrument policy rule developed by Taylor (1993) has become a popular tool for evaluating monetary policy of central banks. As an extensive empirical analysis of the ECB's past behaviour still seems to be in its infancy, we estimate several instrument policy reaction functions for the ECB which might shed some light on actual monetary policy in the euro area in the recent past and answer questions like whether the ECB has actually followed a stabilising or a destabilising rule so far?
Looking at contemporaneous Taylor rules, the presented evidence suggests that the ECB is accommodating changes in inflation and hence follows a destabilising policy. However, this impression seems to be largely due to the lack of a forward-looking perspective in such specifications. Either assuming rational expectations and using a forward-looking specification, or using expectations as derived from surveys result in Taylor rules which do imply a stabilising role of the ECB. The use of real-time industrial production data does not seem to play such a significant role as in the case of the U.S.

JEL Classification: E4, E5.

Keywords: Taylor rule, European Central Bank, real-time data.

Stephan Sauer
University of Munich
Seminar für Makroökonomie
Ludwigstr. 28 Rgb.
80539 Munich
Germany
Stephan.Sauer@lrz.uni-muenchen.de

Jan-Egbert Sturm
University of Konstanz
Department of Economics
P.O. Box D 131
78457 Konstanz
Germany
Jan-Egbert.Sturm@uni-konstanz.de

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1. Introduction

Over the last decade, the simple instrument policy rule developed by Taylor (1993) has become a popular tool for evaluating monetary policy of central banks. Besides numerous papers on the behaviour of the Federal Reserve and other central banks,[1] some authors have applied this rule as a policy guide for the European Central Bank (ECB) in advance of the introduction of the euro in 1999.[2] Since then, the Taylor rule has been used mainly as a rough guide for the evaluation of the ECB policy by many ECB watchers in several periodicals such as 'Monitoring the ECB' by the CEPR. In contrast to that evidence and despite the end of term of ECB's first president, Mr. Duisenberg, an extensive empirical analysis of the ECB's past behaviour still seems to be in its infancy. Referring to its short history, most papers on ECB monetary policy have estimated a Bundesbank or a hypothetical ECB reaction function prior to 1999 and then, e.g. by testing for out-of-sample stability, compared the implied interest rates with actual ECB policy.[3] Only few researchers, such as Fourçans and Vranceanu (2002), Gerdesmeier and Roffia (2003) and Ullrich (2003), have actually estimated an ECB reaction function.

We add to this latter literature by estimating several instrument policy reaction functions for the ECB. In this way we intend to shed some light on actual monetary policy in the euro area. Looking back over the 'Duisenberg-era', we explore what role the output gap has played in actual ECB policy and how actively the ECB has really responded to changes in inflation. By comparing these results with those for the Bundesbank, we hope to get a clearer picture of the new institutional monetary setting in Europe.

In describing actual monetary policy of the ECB by so-called Taylor rules, we will focus on data uncertainties faced by policy-makers. They base their decisions upon data which will most likely be revised in the future. Still most studies on central bank behaviour neglect this issue and use so-called 'current' or 'ex-post' data, i.e. data published in the latest release, to estimate monetary policy rules. In reality, central bankers can only use so-called

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[1] See, e.g. Clarida et al. (1998, 2000), Judd and Rudebusch (1998), Kozicki (1999), Orphanides (2001a), Rudebusch (2002) and Taylor (1999a).

[2] See, e.g. Gerlach and Schnabel (2000) and Peersman and Smets (1998).

[3] See, e.g. Clausen and Hayo (2002), Faust et al. (2001), and Smant (2002) for the first approach and e.g. Clausen and Hayo (2002) and Gerlach-Kristen (2003) for the latter.

'real-time' data, i.e. data available when taking the decision. Croushore and Stark (1999) and Swanson et al. (1999) show that data revisions in the case of the US affect policy analysis and economic forecasts to a substantial degree. In his influential paper, Orphanides (2001a) shows that estimated policy reaction functions obtained using the ex-post revised data can yield misleading descriptions of historical policy in the case of the US. Following Dantuma and De Haan (2003), we explore whether data revisions contain similar problems for the euro area. In this line of argument, the use of survey data which are rarely being revised in the course of time, readily available, and timely (as opposed to most official data) can be very helpful.

A second important aspect of survey data is its prevalent forward-looking perspective. It is well known that central banks not only respond to past information, but use a broad range of information. In particular, they consider forecasts of inflation and output in their decision process. The theoretical justification for such a forward-looking approach is given by, e.g. Clarida et al. (1999) within a New Keynesian model. In addition to investigating policy reaction functions based on survey data, we follow Clarida et al. (1998, 1999, 2000) and estimate forward-looking Taylor rules in order to compare the relevance of real-time versus forward-looking aspects.

We conclude that, without assuming a forward-looking attitude of ECB policy-makers, past policy rate changes are identified as having been too small with respect to changes in inflation and the ECB's policy reaction function does clearly differ from that of the Bundesbank. However, once forward-looking behaviour of the ECB is taken into account, it has followed a stabilising course, i.e. nominal policy rate changes were large enough to actually influence real short term interest rates. In that case, it becomes more difficult to statistically distinguish between the way the Bundesbank has carried out its mandate of achieving price stability in the nineties and the way the ECB has done it since. Specifications using survey information, and therefore combining a forward-looking aspect with the use of real-time data, result in by far the best fit. Unlike for the US, the use of real-time – instead of ex-post data – does not make such a clear difference for any of our conclusions for the euro area.

The next section compares official monetary policy with actual policy as measured by the Taylor rule (Taylor, 1993). Section 3 presents a short overview of the relevant empirical literature. The next two sections present our own results. Amongst others, we exemplify the forward-looking aspect of annual growth rates of industrial production and the use of real-time as well as forward-looking data in estimating Taylor rules for the ECB. We end with some concluding remarks.

2. The Taylor rule

The Maastricht Treaty has made the European Central Bank (ECB) very independent. Nowadays, it is widely believed that a high level of central bank independence and an explicit mandate for the bank to restrain inflation are important institutional devices to assure price stability. It is thought that an independent central bank can give full priority to low levels of inflation. In case of the ECB, its statutes define its primary objective to be price stability, which according to the Governing Council of the ECB is measured by a year-on-year increase of the harmonised index of consumer prices (HICP) for the euro area of below, but close to 2 per cent over the medium term. In countries with a more dependent central bank other considerations (notably, re-election perspectives of politicians and a low level of unemployment) may interfere with the objective of price stability.

The monetary policy strategy of the ECB rests on two ‘pillars’.[4] One pillar gives a prominent role to money. As inflation in the long run is considered to be a monetary phenomenon, the ECB Governing Council has announced a quantitative reference value for the annual growth rate of a broad monetary aggregate (M3). The other pillar is a broadly based assessment both of the outlook regarding price developments and of the risks to price stability in the euro area as a whole. As noted by Issing et al. (2001), a wide range of economic and financial indicator variables – like output gap measures (i.e. measures of the discrepancy between output, or its factors of production, and their equilibrium values) – is used for this purpose.

The above suggests that, like for the US, it might be possible to describe monetary policy in the euro area by a rule depending upon both inflation and output gap developments. A natural starting point is the rule as advocated by Taylor (1993) to describe the monetary policy of the Federal Reserve in the US:[5]

$$i_t = r^* + \pi_t + 0.5\left(\pi_t - \pi^*\right) + 0.5 y_t = \left(r^* - 0.5\pi^*\right) + 1.5\pi_t + 0.5 y_t \, , \qquad (1)$$

[4] The announced changes by the ECB Governing Council on May 8th 2003 are primarily intended to improve communication. For instance, the two pillars have been interchanged and relabelled to stress the way in which information under the two pillars are cross-checked.

[5] As common in this line of literature, the nominal short-term interest rate on the money market is considered to reflect the stance of monetary policy.

where i_t is the policy interest rate, $r*$ the equilibrium real rate, π_t the rate of inflation (as a proxy for expected inflation), $\pi*$ the inflation target and y_t the output gap.

From a theoretical point of view, Svensson (1999) shows that such a rule is the optimal reaction function for a central bank pursuing an inflation target in a simple backward-looking model (using an IS and a Phillips curve).[6] In line with the second pillar of ECB's policy strategy, the output gap is useful in forecasting future inflation and therefore enters the reaction function of the central bank even when it has a strict inflation target.

In order to compare such a Taylor Rule with actual monetary policy, we need to set the equilibrium real interest rate, the inflation target and find proxies for the actual stance of monetary policy, the rate of inflation, and the output gap.[7] With the ECB's inflation target of (close to, but) under 2 per cent and a mean ex-post real interest rate of 1.6 per cent over the period 1999:1-2003:3, Taylor's (1993) original values of $\pi^* = 2$ and $r^* = 2$ for the US should also do reasonably well for the euro area. Actual monetary policy, we measure by the Euro Overnight Index Average (EONIA) lending rate on the money market.[8] Inflation is measured by the year-on-year percentage change in the harmonised index of consumer prices for the euro area, i.e. the price index used by the ECB to measure price stability.[9]

The most difficult variable to quantify in this context is the output gap. Given the relatively short time span since the introduction of the euro and the bi-weekly frequency in which the governing council of the ECB meets and discusses the stance of monetary policy, we follow, e.g. Clarida et al. (1998) and Faust et al. (2001) and use monthly data. This

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[6] For other examples which motivate such a specification theoretically, we refer to Svensson (1996, 1997), Bernanke and Woodford (1997) and Ball (1997).

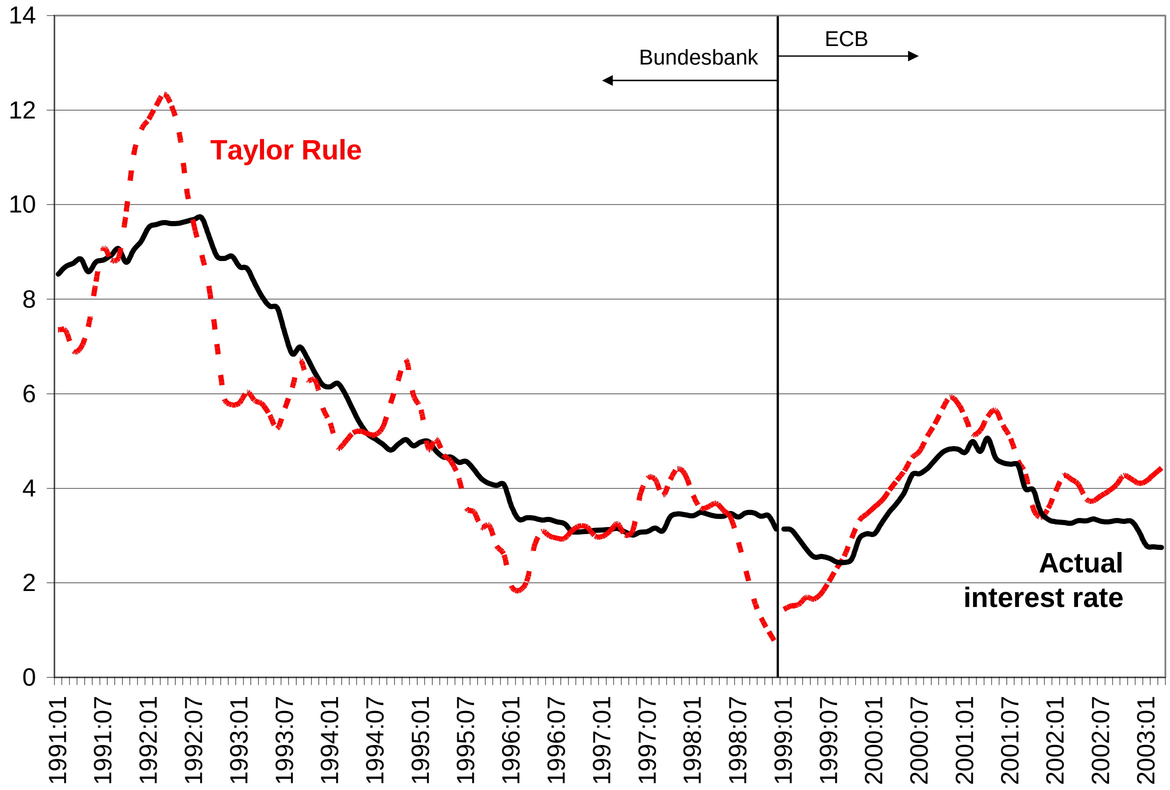
[7] Appendix 1 contains a list of all time series used and their sources.

[8] There is some discussion about what is the correct short-term interest rate for the euro-area. We focus on the EONIA as it is the European equivalent of the Federal Funds rate for the US. Nevertheless, Perez-Quiros and Siciliae (2002) challenge its relevance because of the relatively high volatility when looking at a daily frequency due to short-term liquidity needs. As monthly averages smooth out such movements, this does not appear to be relevant for our study; all results are robust to using the 3-month EURIBOR instead.

[9] We use ex-post available data with respect to the inflation rate, i.e. the major revision of the German CPI as published in March 2003 is included. This revision has reduced inflation rates in the euro area up to 0.5 percentage points mainly in the year 2000. Taking older releases, however, does not change any of our qualitative conclusions (not shown).

restricts our option with respect to an output gap measure. In line with, e.g. Clarida et al. (1998), we take the industrial production index for the euro area, apply a standard Hodrick-Prescott filter (with the smoothing parameter set at $\lambda = 14{,}400$) and calculate our measure of the output gap as the deviation of the logarithm of actual industrial production from its trend.[10] Despite the increasing share of services in the overall economy, it is still generally believed that the industrial sector is the 'cycle maker' in the sense that it leads and influences large parts of the economy.[11]

Figure 1: The nominal interest rate and the Taylor Rule in Germany and the euro area.



Notes: The data before 1999 refer to Germany and monetary policy as conducted by the German Bundesbank. From 1999 onwards, the data refer to the euro area and the ECB. The solid line equals the Frankfurt overnight interest rate / EONIA, whereas the dotted line shows the three months moving average Taylor Rule, in which the inflation rate is measured as the year-to-year percentage change in the Harmonised Index of Consumer Prices (for respectively Germany and the euro area) and the output gap is measured as the deviation of (German / euro area) industrial production from a Hodrick-Prescott filtered trend.

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[10] To calculate a reliable measure of the output gap, we use data for euro area industrial production from 1985 onwards.

[11] As will be discussed later, industrial production data are frequently revised. For that reason, we will also look at real-time industrial production and at the European Sentiment Indicator (ESIN) as measures of the output gap.

Using these measures, Figure 1 depicts actual monetary policy together with the Taylor Rule as given by Equation (1).[12] To enhance comparison with the Bundesbank era, the same graph also shows both time series for Germany using the Frankfurt overnight interest rate and other German counterparts for the remaining series.[13] In general, the coincidence of the actual nominal interest rate and the Taylor Rule is quite striking especially given the sometimes volatile movements in industrial production.[14] Only during two time periods the discrepancy between the two series appears to be relatively persistent: First, in the aftermath of German unification and the following crisis of the European Exchange Rate Mechanism (ERM) until mid-1993 and second, during the second half of 1998 and the first half of 1999. Hence, the change towards the euro seems to have had its effect on actual monetary policy.

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[12] Since our measure of the output gap based on industrial production is more volatile than Taylor's (1993) original GDP-based output gap, it might be argued that it is more appropriate to use a lower weight on y_t than 0.5. Adjusting this weight by the ratio of the standard deviations of the output gaps based on GDP and industrial production (=0.68 for euro area since 1999) does not alter figure 1 in any relevant way.

[13] For the period before 1999, we have also experimented with using industrial production and inflation for the euro area. The data, however, suggest that actual policy of the German Bundesbank has been more concerned with inner German developments.

[14] Using quarterly data and taking deviations of GDP from its trend to measure the output gap results in an even better fit. This explains as of why, e.g. the fit as shown in Figure 1 is not as perfect as in Taylor (1993) for the federal funds rate.

3. An overview of the empirical literature

Using such a simple rule for monetary policy and building on the experience of Taylor (1993), several authors have tried to estimate the weights given to deviations of inflation and output from their optimum by central bankers rather than choosing a symmetric weight of 0.5 as in Equation (1). The general idea of such work is to estimate:

$$i_t = \alpha + g_\pi \pi_t + g_y y_t + \varepsilon_t \,, \qquad (2)$$

where the constant α captures the term $\left(r^* - 0.5\pi^*\right)$ in Equation (1), g_π and g_y represent the estimated weights on inflation and the output gap, respectively, and ε_t is an i.i.d. error term.

An important empirical question relates to the estimated weight on inflation. Since it is the real interest rate which actually drives private decisions, the size of g_π needs to assure that – as a response to a rise in inflation – the nominal interest rate is raised enough to actually increase the real interest rate. This so-called 'Taylor principle' implies this coefficient to be larger than 1.[15] If not, self-fulfilling bursts of inflation may be possible (see e.g., Bernanke and Woodford, 1997; Clarida et al., 1998; Clarida et al., 2000; Woodford, 2001). For monetary policy to have a stabilising influence on output, g_y should be positive.

In practice, it is commonly observed that, especially since the early 1990s, central banks worldwide tend to move policy interest rates in small steps without reversing direction quickly.[16] To capture this so-called interest rate smoothing, Equation (2) is viewed as the mechanism by which the *target* interest rate i_t^* is determined. The *actual* interest rate i_t partially adjusts to this target according to $i_t = (1-\rho)i_t^* + \rho i_{t-1}$, where ρ is the smoothing parameter. This results in the following equation to be estimated:

$$i_t = (1-\rho)\alpha + (1-\rho)\left(g_\pi \pi_t + g_y y_t\right) + \rho i_{t-1} + \varepsilon_t \,, \qquad (3)$$

Table 1 presents a review of different Taylor rule estimations for the euro area and the Bundesbank using monthly or quarterly data. All regressions show that monetary policy prior to 1999 followed the Taylor principle as g_π exceeds 1 consistently. This holds for both Germany as the hypothetical euro area. One reason for the small differences between the

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[15] See, e.g. Taylor (1999b) and Clarida et al. (1998).

[16] See, e.g. Amato and Laubach (1999) and Rudebusch (2002).

Bundesbank and the hypothetical euro area might be the fact that Germany possesses a very large weight in the calculation of the hypothetical euro area interest rate due to its economic size and some authors included merely a subset of all euro member countries in their studies.[17]

Furthermore, note that studies which allow the central banks to behave in a forward-looking manner do not seem to differ significantly from those which do not. This result can be interpreted in different ways. One possibility is that the period of estimation has been relatively stable which would make actual measures of the business cycle and the inflation differential good indicators of (short-term) future developments. In less stable environments – as arguably encountered by the ECB in the last couple of years – this convenient attribute of contemporaneous measures might fail.

With respect to actual ECB policy the story looks rather different; the results of Gerdesmeier and Roffia (2003) and Ullrich (2003) – who use standard output gap measures based on Hodrick-Prescott-filtered industrial production as described above – contradict those of Fourçans and Vranceanu (2002) – who take annual growth rate of industrial production as business cycle measure – and the literature on Taylor rules for both Germany and the hypothetical euro area. While Fourçans and Vranceanu (2002) find the ECB to react strongly to variations in the inflation rate and much less to output variations, both Gerdesmeier and Roffia (2003) and Ullrich (2003) estimate small reactions to inflation movements – suggesting a destabilising role of the ECB – and (both in relative and in absolute terms) strong replies to output deviations. Furthermore, Ullrich (2003) observes a structural break between pre-1999 and post-1999 monetary policy in the euro area.

To summarize, in contrast to the evidence of the Bundesbank and the hypothetical euro area, the actual ECB policy since 1999 does not necessarily seem to comply with the Taylor principle. In the rest of the paper, we intend to shed some more light on this issue by estimating several reaction functions of the ECB and elaborating on the relevance of the output gap measures. Furthermore, we will go into the forward-looking behaviour of actual monetary policy in recent years.

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[17] The striking difference of Clausen and Hayo's (2002) value for euro area g_y in comparison with all other papers and their own value for the Bundesbank might be due to their special estimation technique; they estimate a simultaneous equation model using full information maximum likelihood.

Table 1: Review of Taylor rule estimations for the euro area and the Bundesbank.

Study	Type of rule	Sample period	α	g_π	g_y	ρ
Germany						
Clarida et al. (1998)	Forward-looking	1979:3-1993:12	3.14	1.31	0.25	0.91
			(0.28)	(0.09)	(0.04)	(0.01)
Peersman and Smets (1998)	Forward-looking	1979:1-1997:12	2.52	1.30	0.28	0.93
			(0.32)	(0.10)	(0.05)	(0.01)
Faust et al. (2001)	Forward-looking	1985:1-1998:12	2.85	1.31	0.18	0.91
			(0.85)	(0.35)	(0.16)	(0.03)
Clausen and Hayo (2002)	Contemporaneous	1979:I-1996:IV	3.83	2.89	0.49	0.88
Smant (2002)	Forward-looking	1979:3-1998:12	3.32	1.73	0.45	0.91
			(0.26)	(0.25)	(0.17)	(0.02)
Hypothetical euro area						
Peersman and Smets (1998)	Forward-looking	1980:I-1997:IV	3.87	1.20	0.76	0.76
			(0.44)	(0.09)	(0.13)	(0.13)
Gerlach and Schnabel (2000)	Contemporaneous	1990:I-1998:IV	2.40	1.58	0.45	
			(0.30)	(0.09)	(0.06)	
	Contemporaneous	1990:I-1998:IV	3.90	2.22	0.72	0.32
	Forward-looking	1990:I-1998:IV	2.38	1.84	0.34	0.18
Clausen and Hayo (2002)	Contemporaneous	1979:I-1996:IV	4.07	2.15	2.12	0.86
Gerlach-Kristen (2003)	Contemporaneous	1988:I-2002:II	-1.23	2.73	1.44	0.88
			(1.59)	(0.55)	(0.76)	(0.04)
Ullrich (2003)	Contemporaneous	1995:1-1998:12	1.97	1.25	0.29	0.23
Actual euro area						
Fourçans and Vranceanu (2002)	Contemporaneous	1999:4-2002:2	1.22	1.16	0.18	0.73
				(0.15)	(0.04)	(0.06)
Gerdesmeier and Roffia (2003)	Contemporaneous	1999:1-2002:1	2.60	0.45	0.30	0.72
			(0.20)	(0.10)	(0.03)	(0.04)
Ullrich (2003)	Contemporaneous	1999:1-2002:8	2.96	0.25	0.63	0.19

Notes: Contemporaneous Taylor rules refer to equation (3), forward-looking Taylor rules to equation (5). Standard errors are within parentheses.

4. Contemporaneous rules for the ECB

4.1 Using ex-post data

Table 2 reports the results of estimating equations (2) and (3) using ex-post data. In order to get a clearer impression of the institutional changes related to the ECB taking up monetary policy in the euro area, the regressions have been conducted for the period 1991:1-2003:3. However, all parameters are estimated separately for the Bundesbank (1991:1-1998:12) and the ECB (1999:1-2003:3) period.[18] In this way, we can test whether significant changes have occurred. Without for the time-being going into the details of the different regressions, the last two rows of the table – presenting the results of this Chow test – clearly reject the assumption of identical monetary policy reaction functions. Figure 1 suggests that this might mainly be due to the transition period, i.e. the second half of 1998 and the first half of 1999. To test this, Columns (2) and (4) do not take data from 1998:7-1999:6 into account. Clearly, the results of the Chow test are hardly influenced by this. Hence, Bundesbank policy for Germany during the 1990s clearly differs from ECB policy ever since.

To explain in what way policies diverge, we look at the individual parameter estimates. Column (1) shows the outcomes when estimating Equation (2). The inflation parameter for the ECB period (g_{π}^{ECB}) is higher than the output parameter (g_{y}^{ECB}), but does, however, not exceed one. Hence, the ECB moves to accommodate changes in inflation, but does not increase it sufficiently to keep the real interest rate from declining. This is confirmed by the last row of Table 2, which reports the probability of the ECB inflation parameter to exceed one.

The middle half of Table 2, reporting the extent to which ECB and Bundesbank coefficients differ, shows that the Bundesbank did not pursue such an accommodative strategy. The point estimate for g_{π}^{BuBa} equals (0.51+0.86=) 1.37. The difference between the two point estimates is highly significant. Hence, the Bundesbank more clearly followed a policy stabilising inflation as compared to the ECB. This finding is quite robust in the sense that the difference between the inflation parameters is significantly positive across all specifications tested.

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[18] Changing the sample period for the Bundesbank to 1994:1-1998:12, i.e. excluding the aftermath of German unification and the ERM crisis does not alter our qualitative results.

Table 2: Estimated contemporaneous Taylor rules based on Hodrick-Prescott filtered output gap, 1991:1-2003:3 (with and without transition period).

	(1) $y^{ex\text{-}post}$	(2) $y^{ex\text{-}post}$	(3) $y^{ex\text{-}post}$	(4) $y^{ex\text{-}post}$
	ECB-coefficients			
α^{ECB}	2.58	1.81	3.49	3.17
	(6.35)	(7.12)	(6.83)	(4.19)
g_{π}^{ECB}	0.51	0.85	0.03	0.18
	(2.48)	(5.97)	(0.11)	(0.48)
g_{y}^{ECB}	0.37	0.41	0.76	0.73
	(6.19)	(6.42)	(4.66)	(4.67)
ρ^{ECB}			0.84	0.83
			(19.12)	(15.20)
	Difference BuBa-ECB coefficients			
$\alpha^{BuBa} - \alpha^{ECB}$	-0.80	-0.24	-3.32	-3.20
	(-1.70)	(-0.65)	(-2.58)	(-2.31)
$g_{\pi}^{BuBa} - g_{\pi}^{ECB}$	0.86	0.57	1.22	1.16
	(3.95)	(3.44)	(3.11)	(2.56)
$g_{y}^{BuBa} - g_{y}^{ECB}$	-0.32	-0.36	0.40	0.35
	(-3.78)	(-3.94)	(0.53)	(0.51)
$\rho^{BuBa} - \rho^{ECB}$			0.13	0.14
			(2.67)	(2.41)
# Obs.	147	135	147	135
adj. R2	0.86	0.86	1.00	1.00
DW/Durbin's h	0.29	0.33	-0.01	0.04
Cum. Per. Test	0.65	0.61	0.05	0.06
Engle-Granger	-3.87	-3.97	-14.85	-14.78
Prob $\left(g_{\pi}^{ECB} > 1\right)$	0.01	0.14	0.00	0.02
Chow-test	41.86	14.81	38.46	37.70
p-value	0.00	0.00	0.00	0.00

Notes: Columns (1) and (2) show the results for Equation (2) using OLS with Newey and West (1987) standard errors allowing for serial correlation up to order 3. Column (3) and (4) present non-linear least squares estimates of Equation (3) again using Newey and West (1987) standard errors. Both Columns (2) and (4) exclude the transition period to EMU, i.e. 1998:7-1999:6. The output gap is measured by the Hodrick-Prescott filtered industrial production. The row identified as DW/Durbin's h presents the Durbin-Watson test statistic for Columns (1) and (2) and Durbin's h for Columns (3) and (4). The Durbin Cumulated Periodogram Test (Cum. Per. Test) – a test for general serial correlation using frequency domain techniques – shows the maximum gap between the theoretical spectral distribution function of a white noise process and the actual residuals. In case it is significantly different from zero, we cannot reject the null of general serial correlation. The approximate rejection limits for this test are 0.12 (1%), 0.10 (5%) and 0.09 (10%). The row labelled Engle-Granger denotes the t-statistics of the Engle and Granger (1987) cointegration test. The MacKinnon (1991) critical value using 147 observations and 6 explanatory variables equals -5.42 at the 1 per cent level. The next row shows the probability of the coefficient g_{π}^{ECB} being larger than 1. The null hypothesis of the Chow test is that the coefficients for the Bundesbank and ECB period are the same (i.e. no break). t-statistics are within parentheses.

Furthermore, the row labelled $g_y^{BuBa} - g_y^{ECB}$ reports highly significant differences between the Bundesbank and the ECB with respect to the output variable when estimating Equation (2). The ECB seems to respond much more to changes in the business cycle than the Bundesbank has during the last years in which it determined monetary policy.

A consistent feature of OLS estimates of such simple rules as Equation (2) is a high degree of serial correlation in the error term. Both the low Durbin-Watson statistic and the high maximum gap reported by the Durbin Cumulated Periodogram test clearly indicate severe problems with respect to serial correlation in the error term.[19] Furthermore, the Engle and Granger (1987) cointegration test indicate that the residuals are non-stationary, which implies that at least some variables are non-stationary and indicates that it might be problematic to interpret the estimated coefficients the way we did.[20] While interest rates and inflation are likely to be stationary in large samples, augmented Dickey-Fuller (1979, 1981) tests nevertheless indicate the presence of a unit root in our sample (not shown).[21]

To cope with the non-stationarity of some of our series and to take a possible cointegration relationship into account, we have also applied the fully modified estimator of Phillips and Hansen (1990).[22] This method provides an alternative to the ECM methodology

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[19] As we report Newey and West (1987) standard errors this should – in principle – not affect our ability to interpret the reported standard errors.

[20] We prefer the use of the Engle-Granger cointegration test, instead of the Durbin-Watson test on cointegration, because "[t]he use of [the Durbin-Watson] statistic is problematic in the present setting. First, the test statistic for co-integration depends upon the number of regressors in the co-integrating equation and, more generally, on the data-generation process and hence on the precise data matrix. Second, the bounds diverge as the number of regressors is increased, and eventually cease to have any practical value for the purpose of inference. Finally, the statistic assumes the null where [the residual vector] is a random walk, and the alternative where [the residual vector] is a stationary first-order autoregressive process (…). However, the tabulated bounds are not correct if there is higher-order residual autocorrelation, as will commonly occur." (Banerjee et al., 1993, p. 207)

[21] By using the Hodrick-Prescott filter to calculate our measure of the output gap, this variable is by construction stationary. This is confirmed by augmented Dickey-Fuller tests. However, according to, e.g. Nelson and Plosser (1982) or Harvey and Jaeger (1993), the use of the Hodrick-Prescott filter might create artificial business cycles in the output gap variable (if the underlying industrial production series is non-stationary). A solution to this potential problem is the use of (stationary) survey data.

[22] The underlying idea of cointegration is that non-stationary time series (such as interest and inflation rates) can move apart in the short run, but will be brought back to an equilibrium relation in the long run.

that is of growing popularity in empirical research.[23] As shown in Phillips (1988), the semi-parametric fully modified method and the parametric ECM approach are asymptotically equivalent in some cases. In other cases (characterized by feedback among the innovations) the fully modified method is preferable in terms of asymptotic behaviour. The fully modified estimation results (not shown) do not differ much from the results presented in the first columns. The point estimate for the ECB inflation parameter is even nearly identical. The ECB output parameter, and the differences between the Bundesbank and ECB period are generally found to be larger, albeit less significant.[24]

The other more conventional answer to the reported high serial correlation in the residuals of Equation (2) is to include a lagged interest rate as an additional explanatory variable and hence turn to empirical estimates of Equation (3). Column (3) of Table 2 reports the results. The inclusion of the lagged interest rate both improves the fit of the regression and lowers the degree of serial correlation in the errors. Both the Durbin-*h* statistic and the Durbin Cumulated Periodogram test cannot reject the hypothesis that the residuals behave normal. Furthermore, the Engle and Granger cointegration test clearly rejects non-stationarity of the residuals.

As compared to the first column, the ECB inflation parameter reduces in value and its difference to that of the Bundesbank further increases albeit becomes slightly less significant. For the output gap parameter, the point estimate for the ECB becomes larger. However, the difference between the Bundesbank and the ECB is no longer significant. Column (4) shows that these conclusions are not driven by the inclusion of the period 1998:7 until 1999:6 in which the transition towards a single currency took place and appears to have affected monetary policy (see Figure 1).

In general, these results confirm Gerdesmeier and Roffia (2003) and Ullrich (2003) and suggest that the ECB reacts to a rise in expected inflation by raising nominal short-term interest rates by a relatively small amount and thus letting real short-term interest rates decline. As argued before, such accommodating behaviour constitutes a destabilising policy with respect to inflation. Hence, instead of continuing the inflation stabilising policy line as conducted by the Bundesbank, the ECB appears to have followed a policy rather comparable

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[23] See in the present context e.g. Gerlach-Kristen (2003).

[24] As the fully modified OLS method continues to produce similar outcomes to other methods, we will in the remaining of the paper neither report nor discuss them; these results are available upon request.

to the pre-Volcker era of the Federal reserve, for which e.g. Taylor (1999a) and Clarida et al. (2000) have found values for g_π well below one.

4.2 Using real-time data

A general critique to estimated policy rules such as (2) and (3) has been proposed in a sequence of articles by Orphanides (2001a, 2001b, 2002). He suggests that appropriateness of the Taylor rule requires the use of 'real-time' data, i.e. data actually available to the central bank at the time of its decision making. The first step to acknowledge this argument is by referring to expectations and the use of an available information set to form these expectations. Often then – to get rid of the problem of real-time data – rational expectations with unbiased forecast errors with respect to the final data are assumed.[25] However, as shown by Orphanides (2001a, 2001b, 2002), the actual use of real-time data in the case of the Federal Reserve for the U.S. can cause important differences. While he uses information provided by the Greenbook for Federal Reserve Board meetings, we have to rely on publicly available data for the euro area.

In accordance with Coenen et al. (2002), one way to solve this problem is to take real-time data from the ECB's Monthly Bulletin statistics for the HICP and industrial production. The time lag of publication varies between one and two months for the inflation rate[26] and three to four months for the industrial production index.[27] Coenen et al. (2002, table 1) document the extent of revisions of these figures, which can be summarised as being negligible for the inflation rate[28] but substantial and frequent for the industrial production index. For this reason, we focus on the consequences of using real-time data for our measure of the output gap.

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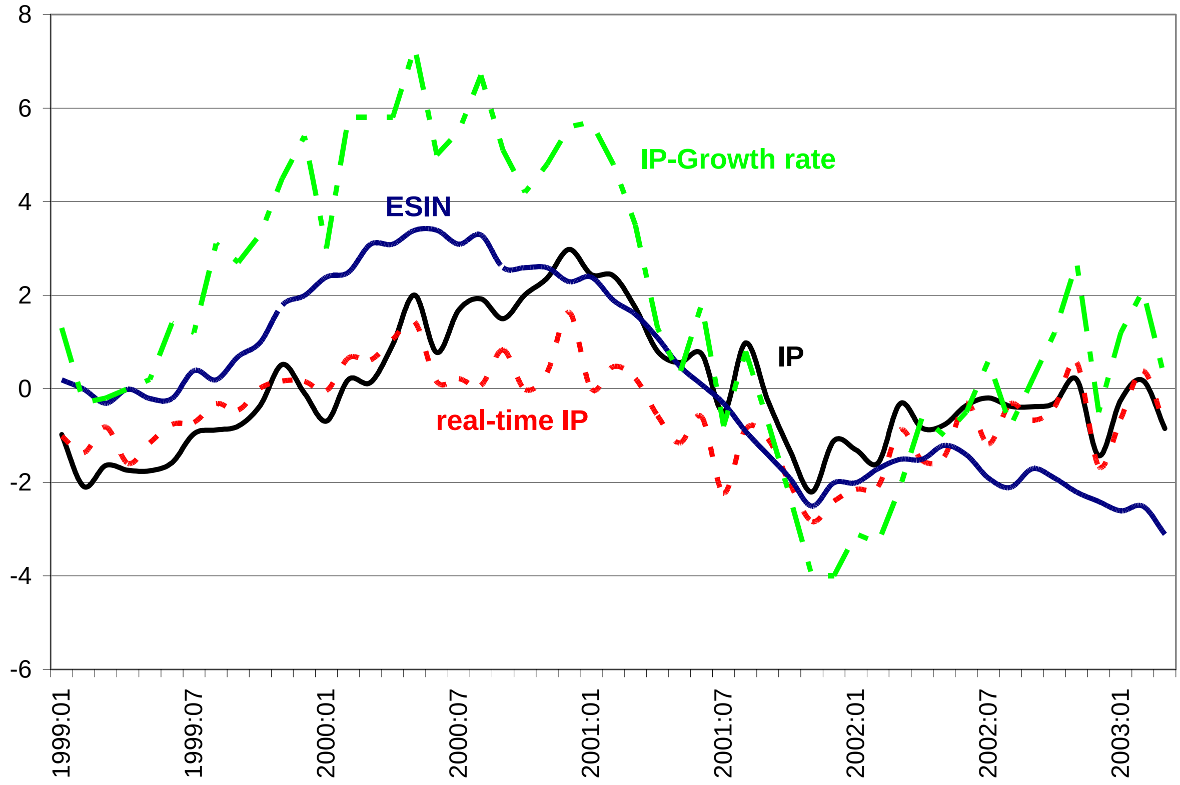
[25] See, e.g. Clarida et al. (1998, 1999, 2000)

[26] Since November 2001 Eurostat base their first estimate on only a selected number of countries. This allows the first estimate to be published one month earlier than before.

[27] In fact, Eurostat releases its figures already one month before they are published in the ECB Monthly Bulletin. Therefore, we will assume that data for month *t*-2 is the latest information available on industrial production in month *t*.

[28] The only noticeable exception is the major revision in March 2003 as mentioned in footnote 9. Nevertheless, using real-time inflation rates does not affect any of our results in any notable way.

Figure 2: Different indicators for the output gap of the euro area.



Notes: The solid line labelled IP stands for the de-trended European industrial production index. The Hodrick-Prescott filter (with λ = 14,400) has been used to de-trend the series. The dotted line IP-Growth rate depicts the annual growth rate of industrial production. The dotted-dashed real-time IP line shows the de-trended European industrial production index this time only using real-time data as explained in the text. The dashed line labelled ESIN depicts the European Economic Sentiment Indicator from which its average over the relevant time period has been subtracted.

Converting our business cycle measure into real time not only involves using real-time industrial production data. In the previous section – and as usual in this line of literature –, we have estimated potential output in one run using all ex-post data available. However, policymakers do not have access to future information necessary to properly calculate potential output. Our monthly measure of the real-time output gap is therefore based only on data available up to two months before the month in question, i.e. potential output is calculated using the Hodrick Prescott filter for each month separately using each time 10 preceding years of data[29] In each run, we use the first release of industrial production for the

[29] To circumvent the end-point problem in calculating potential output using the Hodrick-Prescott filter, we also experimented with taking an autoregressive method to forecast several additional months which are then added

six most recent monthly observations; ex-post data are used for older observations. Hence, we assume that the major revisions will take place within the first half year after release.[30]

Figure 2 shows, amongst others, the different output gap measures as calculated using ex-post data (IP) and the version based on real-time data (real-time IP) since 1999:1, i.e. the ECB period. Especially during the period between July 2000 and the second half of 2001, the use of real-time data clearly underestimates the expansionary phase in which the European industrial sector was situated. This might explain the relatively low interest rate during that period as compared to the Taylor Rule shown in Figure 1.

To investigate the consequences of this 'under-estimation' in real time, Table 3 compares results when using a real-time HP measure of the output gap with those using ex-post data. For ease of presentation, Columns (1) and (3) first replicate the results of Columns (1) and (3) of Table 2, this time focusing on the ECB period only. Columns (2) and (4) report the results using our real-time measure of the output gap for Equation (2) and Equation (3), respectively. The use of real-time data results in the size of the inflation parameter to increase somewhat, without, however, exceeding one. Nevertheless, the last row of Table 3 shows that, instead of having a probability of (nearly) zero of having the inflation parameter to exceed 1, this probability increases to 22 and 18 per cent, respectively.

Albeit the likelihood of the ECB to conduct a stabilising monetary policy has slightly increased to approximately 20%, overall we have to conclude that the use of real-time data does not lead to significantly different results. The explanatory power – as denoted by the adjusted R^2 – even declines (somewhat).

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to the series before applying the Hodrick-Prescott filter. This does not affect the outcomes in a substantial way. To not already introduce some form of forward-looking behaviour, we decided to refrain from doing so at this stage of the analysis.

[30] We experimented with different measures of the real time output gap, e.g. by assuming rational expectations of the ECB with respect to the first release of the data and estimating real-time Taylor rules with GMM. While the point estimates from the different procedures do not differ much, the method proposed in the text leads to the best fit without affecting any of the qualitative conclusions.

Table 3: Estimated contemporaneous Taylor rules using real-time data, 1999:1-2003:3.

	(1) $y^{ex\text{-}post}$	(2) $y^{real\text{-}time}$	(3) $y^{ex\text{-}post}$	(4) $y^{real\text{-}time}$
α^{ECB}	2.58	2.10	3.49	3.13
	(6.35)	(5.41)	(6.83)	(3.14)
g_{π}^{ECB}	0.51	0.84	0.03	0.57
	(2.48)	(4.25)	(0.11)	(1.21)
g_{y}^{ECB}	0.37	0.22	0.76	0.89
	(6.19)	(3.16)	(4.66)	(2.25)
ρ^{ECB}			0.84	0.91
			(19.12)	(19.28)
# Obs.	51	51	51	51
adj. R2	0.67	0.51	0.965	0.959
DW/Durbin's h	0.46	0.22	-0.76	0.09
Cum. Per. Test	0.53	0.62	0.14	0.09
Engle-Granger	-2.41	-1.17	-16.53	-14.71
Prob$\left(g_{\pi}^{ECB} > 1\right)$	0.01	0.22	0.00	0.18

Notes: Columns (1) and (3) use ex-post data. Columns (2) and (4) take de-trended real-time industrial production, shifted back by two months, for the output gap variable. The MacKinnon (1991) critical value using 51 observations and 3 (4) explanatory variables equals -4.59 (-5.48) at the 1 per cent level. See notes of Table 2.

5. Forward-looking rules for the ECB

5.1 Using industrial production growth

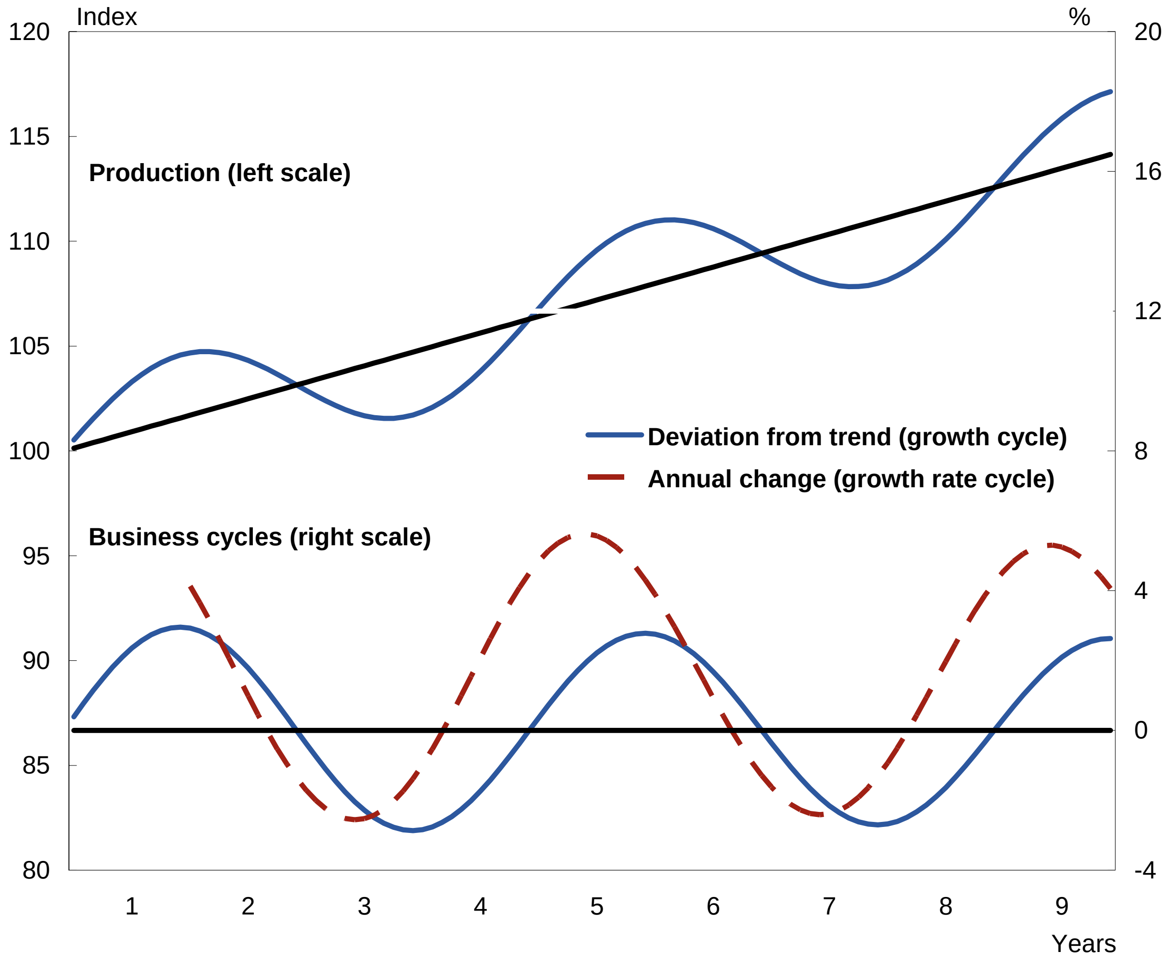
The ECB Governing Council has on several occasions explicitly announced that price stability is to be maintained over the medium term. Since monetary policy operates with a lag, successful stabilisation policy therefore needs to be forward-looking. Hence, an explicitly forward-looking version of the Taylor rule – with inflation and output forecasts as arguments – might be more appropriate than contemporaneous versions as estimated above.

A first step towards a forward-looking monetary policy rule can be achieved by using growth rates (growth rate cycles) of industrial production instead of deviations from potential (growth cycles). Among economic forecasters, the distinction between “classical business cycles”, i.e. fluctuations in actual production levels, “growth cycles”, i.e. fluctuations in deviations of production from its trend and “growth-rate cycles”, i.e. fluctuations in production growth, is well known and explained by, e.g. Nierhaus and Sturm (2003). Figure 3 illustrates the basic idea for the latter two. The lower panel clearly shows that growth and growth-rate cycles are not identical in measuring turning points. In particular, the turning points of growth-rate cycles exhibit a clear lead in comparison to the turning points of growth cycles. Hence, the use of production growth rates – instead of deviations of production from its trend – introduces a forward-looking perspective with respect to the business cycle into the analysis. This is also demonstrated in Figure 2; at least in the expansionary phase, IP-growth rates seem to lead (HP-filtered) IP (and its real-time version, i.e. real-time IP).

Apart from divergent sample periods, this difference in business cycle measures might explain why Fourçans and Vranceanu (2002) report considerably higher g_{π} and lower g_y estimates as compared to our results in Table 2 and the results as reported by Gerdesmeier and Roffia (2003) and Ullrich (2003); Fourçans and Vranceanu (2002) take annual growth of industrial production instead of an output gap measure – as used by all others – to assess the stance of the business cycle.

To check this, we repeat the estimates of Table 2, but replace the Hodrick-Prescott filtered output gap with the annual growth rate of industrial production. Table 4 presents the results.[31] Most interestingly, for all specifications tested, the estimated inflation parameter (g_π) is larger and the estimated output parameter (g_y) smaller than in Table 2. Thus our results at least tend to confirm Fourçans and Vranceanu (2002); apparently introducing a forward-looking aspect makes ECB's monetary policy look less accommodative than before.[32]

Figure 3: Classical Business Cycle and Growth Cycles: 4-year-sinus-oscillation around a linear trend.



Notes: The upper panel depicts a 4-year-sinus-oscillation around a linear production trend. In the lower panel, the solid line shows the percentage deviation of production from the linear trend, the dashed line shows the year-to-year percentage change of the production index.

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[31] To be able to compare the results in Table 4 with those in Table 2 one needs to assume that there has been a constant trend growth rate over the estimated sample period. Given its shortness, this seems to be quite reasonable. The level of this trend growth rate only influences the constant, i.e. neglecting the trend growth rate reduces the constant by the product of g_y and the trend growth rate. This might explain the somewhat lower values of the estimated constants in Table 4 as compared to Tables 2 and 3.

[32] After adjusting the sample period to 1999:4-2002:2 as in Fourçans and Vranceanu (2002), we are able to bring our results even closer to theirs.

Furthermore, note that the estimated differences between the inflation and output parameters for the Bundesbank as compared to those of the ECB become less significant. In Columns (3) and (4), i.e. in the specifications allowing for policy inertia, it even becomes difficult to reject the null hypothesis that the Bundesbank and the ECB have followed the same policy rule (last two rows of Table 4).

Table 4: Estimated Taylor rules based on industrial production growth, 1991:1-2003:3.

	(1) $\hat{y}^{ex\text{-}post}$	(2) $\hat{y}^{ex\text{-}post}$	(3) $\hat{y}^{ex\text{-}post}$	(4) $\hat{y}^{ex\text{-}post}$	(5) $\hat{y}^{real\text{-}time}$	(6) $\hat{y}^{real\text{-}time}$
ECB-coefficients						
α^{ECB}	1.57	0.64	0.75	0.67	1.71	1.71
	(3.67)	(1.77)	(1.04)	(0.61)	(5.86)	(4.03)
g_{π}^{ECB}	0.93	1.32	0.95	1.02	0.85	0.72
	(4.33)	(7.77)	(2.76)	(1.82)	(5.70)	(2.88)
g_{y}^{ECB}	0.10	0.13	0.50	0.47	0.14	0.28
	(2.94)	(3.64)	(2.49)	(2.47)	(6.46)	(3.77)
ρ^{ECB}			0.92	0.91		0.85
			(25.55)	(21.47)		(13.84)
Difference BuBa-ECB coefficients						
$\alpha^{BuBa} - \alpha^{ECB}$	0.23	0.95	-4.60	-4.37		
	(0.47)	(2.06)	(-1.00)	(-1.00)		
$g_{\pi}^{BuBa} - g_{\pi}^{ECB}$	0.44	0.10	1.26	1.20		
	(1.96)	(0.51)	(1.49)	(1.31)		
$g_{y}^{BuBa} - g_{y}^{ECB}$	-0.15	-0.17	3.42	3.05		
	(-0.75)	(-0.81)	(1.01)	(1.01)		
$\rho^{BuBa} - \rho^{ECB}$			0.06	0.07		
			(1.65)	(1.51)		
# Obs.	147	135	147	135	51	51
adj. R2	0.85	0.85	1.00	1.00	0.67	0.96
DW/Durbin's h	0.26	0.30	0.27	0.31	0.42	0.37
Cum. Per. Test	0.64	0.62	0.06	0.07	0.45	0.11
Engle-Granger	-3.79	-4.65	-14.51	-14.44	-5.79	-14.21
Prob$\left(g_{\pi}^{ECB} > 1\right)$	0.37	0.97	0.44	0.51	0.15	0.13
Chow-test	28.29	25.72	7.77	7.82		
p-value	0.00	0.00	0.10	0.10		

Notes: In all columns, the output gap is measured by the annual growth rate of industrial production. Both Columns (2) and (4) exclude the transition period to EMU, i.e. 1998:7-1999:6. Columns (5) and (6) use the real-time growth rate of industrial production, shifted back by two months, for the output gap variable. See notes of Tables 2 and 3.

To explore the consequences of using real-time data, the last two columns of Table 4 show the results in case the ex-post growth rates are replaced by real-time growth rates. The point estimates are somewhat lower, thereby reducing the likelihood that the ECB has in fact followed a stabilising rule to less than 15 per cent. Again the overall explanatory power reduces somewhat (not shown), albeit in general the results are only affected to a minor extent. As before, we therefore have to conclude that differences between ex-post and real-time data do not seem to play an important role when evaluating ECB's monetary policy. To the extent that our results do seem to be affected, it appears to be the consequence of the forward-looking aspect as introduced by using growth rate cycles.

5.2 Using survey data

Another way to include forward-looking elements into the analysis is to use survey information to proxy business cycle movements. As survey information not only becomes available much sooner than statistical information and in general includes questions regarding future developments, it is nowadays widely believed that the former is a good leading indicator for the latter.

Since 1962 – the year in which the first harmonised business survey in industry for the EU was launched – there has been a spectacular growth of business and consumer surveys. This allowed the scope and sectors covered by such surveys to expand over time. Since 1985, the European Commission publishes the composite EU Economic Sentiment Indicator (ESIN) on a monthly basis.[33] The ESIN provides a picture of economic activity one to two months before industrial production statistics become available.[34]

Figure 2 shows the deviations of the ESIN from its average together with our other three indicators for the output gap. In general, the patterns of these four indicators are rather similar. The only differences are in timing – both the ESIN and the IP-growth rate clearly lead the other two indicators – and in volatility – the ESIN is clearly the least volatile measure.

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[33] The EU ESIN comprises of an industrial confidence indicator, a consumer confidence indicator, a construction confidence indicator, and a retail trade confidence indicator.

[34] For the relevance of ESIN as a business cycle indicator for the EU, see e.g. Goldrian et al. (2001).

Table 5: Estimated forward-looking Taylor rules using survey data, 1999:1-2003:3.

	(1) y^{ESIN}	(2) $+\pi^{forecast}$	(3) y^{ESIN}	(4) $+\pi^{forecast}$
α^{ECB}	1.61	0.31	1.41	0.31
	(4.35)	(0.46)	(3.25)	(0.47)
g_{π}^{ECB}	0.98	1.93	1.04	1.88
	(5.72)	(5.25)	(5.02)	(5.16)
g_{y}^{ECB}	0.22	0.17	0.51	0.44
	(4.25)	(4.11)	(7.33)	(6.87)
ρ^{ECB}			0.85	0.84
			(29.90)	(26.47)
# Obs.	51	51	51	51
adj. R2	0.65	0.71	0.97	0.97
DW/Durbin's h	0.28	0.28	-1.45	-1.18
Cum. Per. Test	0.59	0.65	0.17	0.15
Engle-Granger	-2.10	-2.06	-18.41	-17.65
Prob$\left(g_{\pi}^{ECB} > 1\right)$	0.46	0.99	0.57	0.99

Notes: Columns (1) and (3) take the European Sentiment Indicator (ESIN) as output gap measure. Columns (2) and (4) also use forecasted inflation as published in "The Economist". See notes of Tables 2 and 3.

By taking the ESIN as our output gap measure into the regressions, the inflation parameter gets close to – or even slightly larger than – one (Columns (1) and (3) of Table 5). The probability of the ECB stabilising inflation increases to approximately 50 per cent (coming from zero in Columns (1) and (3) of Table 3). The output parameter reduces slightly in size without losing significance. All this reinforces our previously cautious conclusion that ECB's apparent accommodative behaviour can be explained by differences between contemporaneous and forward-looking data.

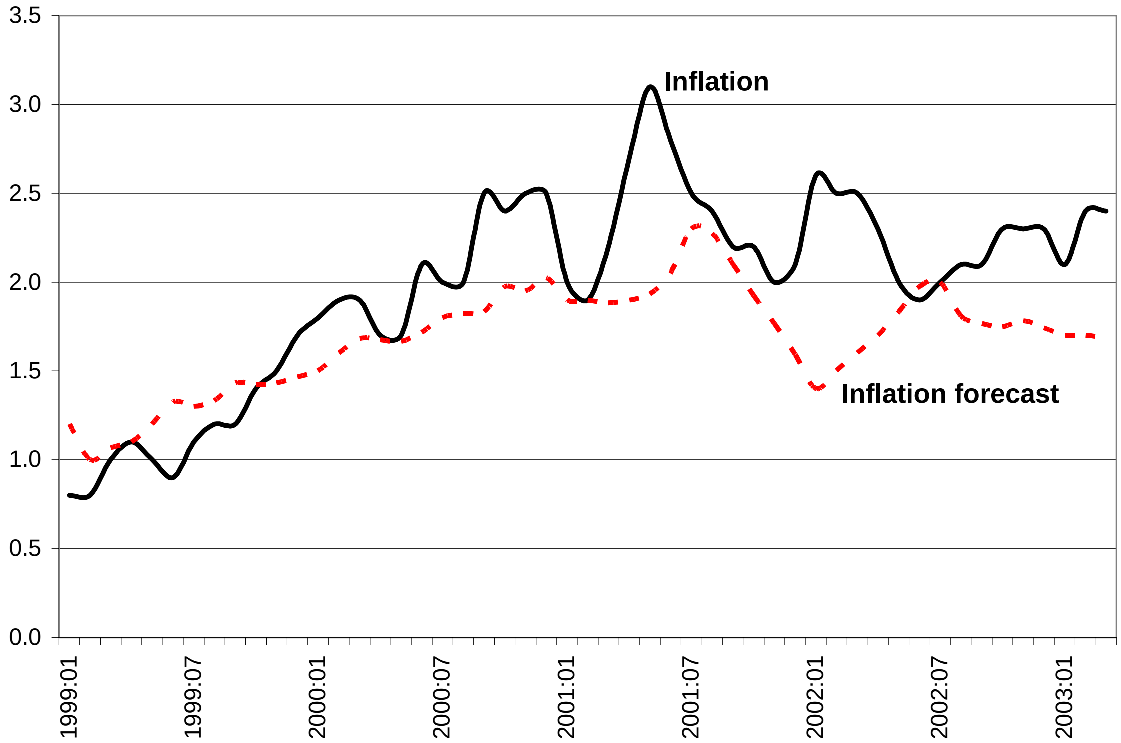
Instead of relying on the statistical releases of the inflation rate, we can also use survey results to get an idea of inflation developments. The newspaper *The Economist* publishes inflation forecasts based on a poll of a group of forecasters every month.[35] Figure 4 shows these survey forecasts together with our regular inflation measure. The inflation forecast

[35] Unfortunately, these figures are only annual average inflation rates, not true 12-month inflation forecasts. To convert these into monthly moving figures, we take as the 12-month forecast of inflation the weighted average of the forecast for the current and the following year, where the weights are $x/12$ for the x remaining months in the current year and $(12-x)/12$ for the following year's forecast. See also Smant (2002, p.7).

measure is less volatile and – to the extent that it does lead actual inflation – the lead is roughly half a year.

Columns (2) and (4) of Table 5 show the results in case we combine both forward-looking survey measures, i.e. replace actual inflation in Columns (1) and (3) by this inflation forecast measure. Independent of the specification of the equation, this shows the best results overall. In both specifications, the inflation parameter is – with a probability of close to 100 per cent – larger than one without significantly affecting the output parameter. Hence, taking these survey measures as proxies for our theoretical output gap and inflation differential variables shows that the ECB has appeared to have followed a stabilising policy rule with respect to both.

Figure 4: Different indicators for inflation in the euro area.



Notes: The solid line labelled shows the year-to-year percentage change of the harmonised index (HICP) of consumer price for the euro area. The dotted line shows the inflation forecasts taken from "The Economist".

5.3 Using HP-filtered industrial production

As survey measures also bear real-time aspects – they are usually available without long time lags and without substantial revisions – it could be argued that the improved results in Table 5 (as compared to Table 2) should be attributed to the use of real-time data instead of taking a forward-looking perspective. However, note that the use of real-time data in so-called contemporaneous rules (Table 3 and to some extent Table 4) seems to reject that hypothesis. To nevertheless shed some additional light on this, we will now estimate explicitly forward-looking models in which ex-post and real-time data on industrial production are used.

As an enhancement of the standard Taylor-rule framework, many economists follow Clarida et al. (1998) and use a forward-looking rule, where the target interest rate i_t^* is set in response to expected inflation and output. Expectations are based on the available information set Ω at time *t* and reach *k* and *l* periods into the future, respectively.

$$i_t = \alpha + g_\pi E(\pi_{t+k} \mid \Omega_t) + g_y E(y_{t+l} \mid \Omega_t) + \varepsilon_t \tag{4}$$

$$i_t = (1-\rho)\alpha + (1-\rho)\left(g_\pi E(\pi_{t+k} \mid \Omega_t) + g_y E(y_{t+l} \mid \Omega_t)\right) + \rho i_{t-1} + \varepsilon_t \tag{5}$$

Assuming rational expectations, these equations are estimated using the generalised method of moments (GMM). Table 6 reports results for $k = l = 3$.[36]

Independent of whether we use ex-post or real-time data to measure the output gap, or whether we use growth or growth rate cycles, the inflation parameter is larger than (or in case of Column (4) relatively close to) one with high probability. Hence, by explicitly including forward-looking behaviour on account of the ECB, monetary policy in recent years has – at least ex ante – been sufficiently aggressive to stabilise inflation in the euro area. Especially in the case of Equation (3) (i.e. Column (5)), the use of real-time data as compared to ex-post data seems to strengthen this result even further. From Table 3, however, we know that it is not sufficient to use real-time data in a contemporaneous set-up. Without taking a forward-looking perspective, ECB's monetary policy cannot be considered to have stabilised inflation.

Comparing the results in Table 6 with those in Table 5 reveals that the use of survey data results in a better fit than does the use of industrial production data in a forward-looking specification like Equation (4) or (5).

[36] The set of instruments are three lags of the inflation and output gap corresponding to data employed in the regression, and – in case we model interest rate smoothing – the money market rate.

Table 6: Estimated forward-looking Taylor rules using GMM, 1999:1-2003:3.

	(1) $y^{ex\text{-}post}$	(2) $y^{real\text{-}time}$	(3) $\hat{y}^{real\text{-}time}$	(4) $y^{ex\text{-}post}$	(5) $y^{real\text{-}time}$	(6) $\hat{y}^{real\text{-}time}$
α^{ECB}	0.48	0.52	0.02	1.72	0.25	0.02
	(0.54)	(0.63)	(0.03)	(1.98)	(0.21)	(0.04)
g_{π}^{ECB}	1.47	1.59	1.64	0.86	2.31	1.56
	(3.52)	(4.39)	(4.10)	(1.95)	(3.79)	(6.02)
g_{y}^{ECB}	0.32	0.38	0.09	0.86	2.35	0.28
	(2.35)	(2.49)	(2.92)	(3.27)	(2.25)	(4.62)
ρ^{ECB}				0.88	0.92	0.87
				(25.21)	(30.10)	(35.63)
# Obs.	48	48	47	48	48	47
adj. R2	0.18	0.32	0.34	0.96	0.96	0.96
DW/Durbin's h	0.38	0.38	0.39	-1.02	-1.76	-1.49
Cum. Per. Test	0.49	0.50	0.51	0.17	0.22	0.20
Engle-Granger	-2.86	-2.36	-2.37	-14.05	-15.81	-14.83
Prob $\left(g_{\pi}^{ECB} > 1\right)$	0.87	0.95	0.94	0.38	0.98	0.98

Notes: Under rational expectations, three months forward-looking estimates of inflation and the output gap are used, i.e. in all equations we set $k = l = 3$. The results are estimated by the Generalised Method of Moments (GMM) with Newey-West heteroscedastity and serial correlation robust estimators. As instruments, we use up to three months lagged inflation and output gaps corresponding to data employed in the regression, and – in case we model interest rate smoothing – interest rates. Columns (1) and (4) use ex-post data. Columns (2) and (5) take de-trended real-time industrial production, shifted back by two months, for the output gap variable. Columns (3) and (6) do the same, but replace de-trended real-time industrial production by the real-time growth rate of industrial production. The approximate rejection limits for the Durbin Cumulated Periodogram Test (Cum. Per. Test) are 0.17 (1%), 0.14 (5%) and 0.12 (10%). The MacKinnon (1991) critical value using 47 observations and 3 (4) explanatory variables equals -4.61 (-5.04) at the 1 per cent level. See notes of Tables 2 and 3.

6. Concluding remarks

In this paper we have explored different ECB Taylor Rules for the euro area. We have asked ourselves, whether or not the ECB has in its first years of existence under the presidency of Mr. Duisenberg been following a stabilising or a destabilising rule. Already Faust et al. (2001) argue that the ECB puts too high a weight on the output gap relative to inflation and in comparison to the Bundesbank.

Looking at contemporaneous Taylor rules, the presented evidence clearly confirms previous research and suggests that the ECB is accommodating changes in inflation and hence follows a destabilising policy. The differences between the Bundesbank and the ECB are significant. Such an interpretation gives rise to the conjecture that the ECB follows a policy quite similar to the pre-Volcker era of US monetary policy, a time also known as the 'Great Inflation' (Taylor, 1999a).[37]

However, this impression seems to be largely due to the lack of a forward-looking perspective. Already turning to growth rate cycles, which allows turning point to be discovered earlier, makes it sometimes hard to distinguish between the policy rule followed by the Bundesbank versus that of the ECB. Furthermore, by either assuming rational expectations and using a forward-looking specification as suggested by Clarida et al. (1998) or using expectations as derived from surveys result in Taylor rules which do imply a stabilising role of the ECB. The use of real-time industrial production data, as suggested by Orphanides (2001b), hardly helps in this respect.

Our preferred specification involves the use of survey data; their real-time character combined with their forward-looking nature seems to produce the best results, in the sense that its explanatory power is the largest and the parameters do confirm a stabilising role for the ECB. Furthermore, an important advantage of survey data is that one does not have to rely upon (artificial) decomposition methods like the Hodrick-Prescott filter introducing several additional problems – problems which we barely touched upon in this paper.

Nevertheless, some words of caution are in order here. One possible other explanation for our (ex-post) results is given by Clarida et al. (2000, p. 154) who argue that a short sample with little variability in inflation, especially with only small deviations from the target rate,

[37] Taylor (1999a) finds values of $g_\pi = 0.81$ and $g_y = 0.25$ with ex-post data for the US for that period, while Orphanides (2001b) estimates a forward-looking rule with real-time data and reports $g_\pi = 1.64$ and $g_y = 0.57$.

might lead to too low an estimate of the inflation parameter. So far, data are only available for one business cycle and the actual inflation rate is close to the target the ECB has set itself. In that sense, recent inflation rates are not at all comparable to those during the 1970s. It is also highly probable that the ECB would act much more aggressively against larger deviations of the inflation rate from its own goal than can be seen in the data so far. As suggested by e.g. Clarida and Gertler (1996), central banks react differently to expected inflation above trend as compared to expected inflation below trend. They show that the German Bundesbank clearly reacted in the former case, whereas in the latter case they hardly responded. Given data limitations it is too early to tell whether or not the same holds for the ECB.

A final result is that the data show a large degree of partial adjustment in the interest rate, i.e. short-term interest rates tend to be changed in several sequential steps in one direction. In principal, this could imply that policy responds too little and too late to changes in economic environment. Rudebusch (2002) reports comparable outcomes for the US. In contrast to the conventional wisdom that the Federal Reserve smoothes adjustments in the interest rate, Rudebusch argues – based on quarterly data – that this view is an illusion and the apparent inertia rather reflect persistent shocks to the economy.[38] Whether this is also true for the ECB is a question that is left for future research.

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[38] Sack and Wieland (2000) offer three explanations of interest-rate smoothing: forward-looking behaviour by market participants, measurement error associated with key macroeconomic variables, and uncertainty regarding relevant structural parameters.

References

Amato, J.D. and T. Laubach (1999), The value of interest-rate smoothing: How the private sector helps the Federal Reserve, *Federal Reserve Bank of Kansas City Economic Review*, 84 (3), pp. 47-64.

Ball, L. (1997), *Efficient rules for monetary stability*, NBER Working Paper No. 5952, NBER, Cambridge, MA.

Banerjee, A., J.J. Dolado, J.W. Galbraith and D.F. Hendry (1993), *Co-integration, error-correction, and the econometric analysis of non-stationary data*, Oxford University Press, New York.

Bernanke, B. and M. Woodford (1997), Inflation forecasts and monetary policy, *Journal of Money, Credit, and Banking*, 24, 653-684.

Clarida, R. and M. Gertler (1996), *How the Bundesbank conducts monetary policy*, NBER Working Paper No. 5581, NBER, Cambridge, MA.

Clarida, R., J. Galí, and M. Gertler (1998), Monetary policy rules in practise: some international evidence, *European Economic Review*, 42, 1033-1067.

Clarida, R., J. Galí, and M. Gertler (1999), The science of monetary policy: a new Keynesian perspective, *Journal of Economic Literature*, 37(4), 1661-1707.

Clarida, R., J. Galí and M. Gertler (2000), Monetary policy rules and macroeconomic stability: evidence and some theory, *Quarterly Journal of Economics*, 115, 147-180.

Clausen, V. and B. Hayo (2002), *Monetary Policy in the Euro Area – Lessons from the First Years*. ZEI Working Paper B 02-09.

Coenen, G., A. Levin and V. Wieland (2002), *Data Uncertainty and the Role of Money as an Information Variable for Monetary Policy*, mimeo. (Revised version of ECB Working Paper Series No. 84, November 2001.)

Croushore, D. and T. Stark (1999), *A real-time data set for macroeconomists*, Federal Reserve Bank of Philadelphia, Working Paper 99-4.

Dantuma, E. and J. De Haan (2003), *Monetair beleid in Duitsland: real time vs ex post data*, University of Groningen, mimeo.

Dickey, D.A. and W.A. Fuller (1979), Distribution of the estimates for autoregressive time series with a unit root, *Journal of the American Statistical Association*, 74, 427-431.

Dickey, D.A. and W.A. Fuller (1981), Likelihood ratio statistics for autoregressive time series with a unit root, *Econometrica*, 49(4), 1057-1072.

Engle, R.F. and C.W.J. Granger (1987), Co-integration and error correction: representation, estimation, and testing, *Econometrica*, 55(2), 251-276.

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

Fourçans, A. and R. Vranceanu (2002), *ECB Monetary Policy Rule: Some Theory and Empirical Evidence*, ESSEC Working Paper No. 02008 (forthcoming in: *European Journal of Political Economy*).

Gerdesmeier, D. and B. Roffia (2003), *Empirical estimates of reaction functions for the euro area*, ECB Working Paper Series No. 206.

Gerlach, S. and G. Schnabel (2000), The Taylor rule and interest rates in the EMU area, *Economics Letters*, 67, 165-171.

Gerlach-Kristen, P. (2003), *Interest rate reaction function and the Taylor rule in the euro area*, ECB Working Paper Series No. 258.

Goldrian, G., J.D. Lindlbauer and G. Nerb (2001), *Evaluation and development of confidence indicators based on harmonised business and consumer surveys*, Economic Paper by Directorate General Economic and Financial Affairs, Number 151. http://europa.eu.int/economy_finance

Harvey, A.C. and A. Jaeger (1993), Detrending, Stylized Facts and the Business Cycle, *Journal of Econometrics*, 8, 231-247.

Issing, O., V. Gaspar, I. Angeloni and O. Tristani (2001), *Monetary Policy in the Euro Area. Strategy and Decision-Making at the European Central Bank*, Cambridge: Cambridge University Press.

Judd, J. P., and G. D. Rudebusch (1998), Taylor's Rule and the Fed: 1970-1997, *FRBSF Economic Review*, (3), 3-16.

Kozicki, S. (1999), How Useful are Taylor Rules for Monetary Policy, *Economic Review, Federal Reserve Bank of Kansas City*, 5-33.

Nierhaus, W. and J.-E. Sturm (2003), Methoden der Konjunkturprognose. *Ifo Schnelldienst* 56(4), 7-23.

Nelson, C.R. and C.I. Plosser (1982), Trends and Random Walks in macroeconomic time series: some evidence and implications, *Journal of Monetary Economics*, 10(2), 139-62.

Newey, W. and K. West (1987). A Simple Positive-Definite Heteroskedasticity and Autocorrelation Consistent Covariance Matrix, *Econometrica*, 55, 703-708.

Orphanides, A. (2001a), Monetary Policy Rules Based on Real-Time Data, *American Economic Review*, 91(4), 964-985.

Orphanides, A. (2001b), *Monetary Policy Rules, Macroeconomic Stability and Inflation: A View from the Trenches*, Federal Reserve Board, Finance and Economics Discussion Series No. 2001-62.

Orphanides, A. (2002) Monetary-Policy Rules and the Great Inflation. *American Economic Review*, 92(2), 115-120.

Peersman G. and F. Smets (1998), *Uncertainty and the Taylor rule in a simple model of the euro-area economy*, Ghent University Working Paper.

Perez-Quiros, G. and J. Siciliae (2002), *Is the European Central Bank (and the United States Federal Reserve) predictable?*, ECB Working Paper Series No. 192.

Phillips, P.C.B. (1988), Reflections on Econometric Methodology, *The Economic Record*, December, 344-359.

Phillips, P.C.B. and B.E. Hansen (1990), Statistical inference in instrumental variables regressions with I(1) processes, *Review of Economic Studies*, 57(1), 99-125.

Rudebusch, G.D. (2002), Term structure evidence on interest-rate smoothing and monetary policy inertia, *Journal of Monetary Economics*, 49, 1161-1187.

Sack B. and V. Wieland (2000), Interest-rate smoothing and optimal monetary policy: A review of recent empirical evidence, *Journal of Economics and Business*, 52, 205-228.

Smant, D.J.C. (2002), Has the European Central Bank followed a Bundesbank policy? Evidence from the early years. *Kredit und Kapital*, 35 (3), 327-43.

Svensson, L.O. (1996), *Inflation forecast targeting: Implementing and monitoring inflation targets*, NBER Working Paper No. 5797, NBER, Cambridge, MA.

Svensson, L.O. (1997), *Inflation targeting: Some extensions*, NBER Working Paper No. 5962, NBER, Cambridge, MA.

Svensson, L.O. (1999), Inflation targeting: some extensions, *Scandinavian Journal of Economics*, 101 (3), 337-361.

Swanson, N.R., E. Ghysels and M. Callan (1999), A Multivariate Time Series Analysis of the Data Revision Process for Industrial Production and the Composite Leading Indicator. Cointegration, Causality and Forecasting: Festschrift in Honor of Clive W.J. Granger.

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

Taylor, J.B. (1999a), A historical analysis of monetary policy rules, in: J.B. Taylor (ed.), *Monetary Policy Rules*, Chicago: University of Chicago.

Taylor, J.B. (1999b), The robustness and efficiency of monetary policy rules as guidelines for interest rate setting by the European Central Bank, *Journal of Monetary Economics*, 43.

Ullrich, K. (2003), *A Comparison Between the Fed and the ECB: Taylor Rules*, ZEW Discussion Paper No. 03-19, Mannheim.

Woodford, M. (2001), The Taylor Rule and Optimal Monetary Policy, *American Economic Review*, 91(2), 232-237.

Appendix 1: Data

Interest rates

For the nominal interest rate of the euro area we take the Euro Overnight Index Average (EONIA). In case of Germany we use the Frankfurt Interbank Offered Rate Overnight. Both interest rates are provided as monthly averages by the Bundesbank's time series data base:

http://www.bundesbank.de/stat/zeitreihen/index.htm

Inflation rates

Annual inflation for the euro area is measured by the harmonised index of consumer prices (HICP). This series is not adjusted for seasonally effects and is taken from the ECB website:

http://www.ecb.int/stats/mb/eastats.htm

For Germany, we take the annual inflation rate based on the consumer price index (CPI) (not seasonally adjusted) as published by the German Statistisches Bundesamt. Both series are from Datastream.

Real-time inflation for the euro area is based on first published figures for the respective month of inflation euro area as described above and are taken from the ECB Monthly Bulletins. The inflation forecasts are based on data published by the newspaper *The Economist*. The calculation of each monthly data point is described in footnote 35.

Output gap measures

As first measure for the output gap, we take the European industrial production index starting in 1985, apply a standard Hodrick-Prescott filter with the smoothing parameter of $\lambda = 14{,}400$ and calculate the output gap as the deviation of logarithm of actual industrial production from trend. Our measure of the euro-area industrial production index excludes construction and is seasonally and working day adjusted and is taken from the ECB website.

Alternative estimates of the output gap include a "real-time" industrial production index and the European Sentiment Indicator (ESIN). The former consists of first published figures for the respective months and is collected from the ECB Monthly Bulletins. The latter, which is a weighted combination of an industrial confidence indicator, a consumer confidence indicator, a construction confidence indicator, and a retail trade confidence indicator, is taken from the European Commission website:

http://europa.eu.int/comm/economy_finance/indicators/business_consumer_surveys/bcsseries_en.htm

German industrial production is seasonally adjusted and taken from Eurostat.

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